The Risk-Shifting Hypothesis: Evidence from Sub-Prime Originations

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Abstract

Using loan level data, we provide evidence consistent with risk-shifting in the lending behavior of a large subprime mortgage originator – New Century Financial Corporation – starting in 2004. This change follows the monetary policy tightening implemented by the Fed in the spring of 2004, which resulted in an adverse shock to the large portfolio of loans New Century was holding for investment. New Century reacted to this shock by massively resorting to deferred amortization loan contracts ("interest-only" loans). We show that these loans were not only riskier, but also that their returns were by design more sensitive to real estate prices than standard contracts. New Century was thus financing projects with a high beta on its own survival, as predicted by a standard model of portfolio selection in financial distress. Our findings contribute to better characterizing the type of risk taken by financially distressed firms. They also shed new light on the relationship between monetary policy and risk taking by financial institutions.

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1. Introduction

Financial institutions, when in distress, may take excessive risk. Because they do not bear the losses in case of failure, shareholders of distressed banks have a natural preference for risky lending, fueling asset bubbles, banking crises and prolonged recessions (Allen and Gale, 2000). The literature provides several examples of distressed banks engaged in value-destroying investments decisions (e.g., Esty, 1997, Gan, 2004). Most evidence on risk-shifting relies on the observation of broad categories of investment by distressed firms (for instance "investing in real estate"). Such a low level of granularity makes it hard to distinguish the risk-shifting hypothesis from a simple "looting view", whereby managers simply confiscate value from other stakeholders, without it being driven by change in risk preferences. Yet, understanding the exact distortion generated by financial distress is important for the design of both prudential regulation and bankruptcy law (Akerlov and Romer, 1993). Our goal in this paper is thus to provide direct evidence of risk shifting in a large financial institution. To this end, we use the internal records of a major subprime originator, New Century Financial Corporation (NC). NC is a good candidate to study risk-shifting: in 2004, its payout ratio went up from 5% to 90%, consistent with textbook asset substitution (Figure 1). Against this background, our project-level (loan-level) data allows us to accurately characterize the distortion in risk preferences induced by financial distress.

We start with a simple illustrative model that characterizes project choice in financial distress. In our model, financial distress distorts shareholders' preferences towards investments that payoff more in the states of nature where the firm does not default. A simple calibration exercise shows that this distortion can be sizable even under a relatively low probability of bankruptcy: projects with large negative NPV can be selected by shareholders provided they have a sufficiently strong covariance with the firm's survival. In other words, the firm needs not be near bankruptcy to risk-shift.

We apply the basic insights of our model to New Century (henceforth NC), the second largest subprime mortgage originator in the U.S. during from 2004 to 2007. We first document that NC was at risk financially as early as 2004. Since 2003, a significant fraction (about 20%) of NC's originations were kept on its balance sheet as long-term investment. As a result, its leverage increased dramatically from 2002 to 2004, up to 90% in 2004. The monetary tightening implemented by the Fed at this time impaired NC's franchise value, mostly for two reasons: (1) a massive balance sheet mismatch, as many loans paid fixed rates but were financed with flexible rates (2) an increase in the repayment risk of flexible rate mortgages made to subprime households whose monthly repayments would predictably increase. Regulatory shocks, competition, as well as the progressive saturation of the real estate market, further increased the pressure on New Century's shareholders.[1] An indirect indication of financial distress is the remarkable increase in payout ratio, from 6% until 2003 to 95% in 2005Q1.[2]

Because of the large loan portfolio held on its balance sheet, NC's survival was inherently tied to real estate prices. In this context, our model delivers three precise testable predictions. First, when closer to financial distress, NC should originate loans whose repayments are more sensitive to house price growth. The economic intuition is direct: because NC would be bankrupt in case of a collapse in real estate prices, loans with a high exposure to real estate prices were more attractive to NC shareholders. This explains an important change in NC's issuance policy in 2004, namely the issuance of "interest-only" loans, who grew massively from 2 to 20% of total originations in 2004. Due to their delayed amortization feature, these loans exhibit a massive increase in due repayments 24 months after origination. As a result, many borrowers need a refinancing when the interest-only period expires.[3] However, refinancing is only possible if the borrower has built enough equity in the house, which for an "interest-only" loan happens only through price increases (as borrowers do not repay the

[1] The top executives of New Century had significant incentives to maximize shareholder value. Between 2001 and 2005, the dollar stake of NC's three founder-managers went up from $42M to $147M (Source: EXECUCOMP). Nor is there much evidence that the founders tried to cash out before bankruptcy. Between 2003 and 2007, they sold less stocks than they were granted (Source: SEC).

[2] Source: COMPUSTAT. The company became a REIT in the last quarter of 2004.

[3] In contrast to prime mortgages, prepayment was an integral part of the business model of subprime lending (Gerardi et al, 2009)

principal) . Therefore, the repayment of interest-only loans depends more strongly on real estate prices than for other types of loans. This feature of interest-only loans is evident when we analyze NC's internal records on repayments. Supporting this risk-shifting interpretation of the switch to interest-only loans, we find a revealing modification of wording (within an otherwise similar paragraph) in the 2004 10k compared to the 2003 one: In its description of criteria used to approve interest-only loan applications, New Century erased in the 2004 10k an important restriction that used to be applied before that year in the evaluation of the repayment ability of borrowers.

NC was not isolated in this increased use of deferred amortization loans. Using information from 10K filings, we find that originators with more "skin in the game" (i.e. originators who held more loans as long-term investment in 2003) originated larger amounts of deferred amortization loans in 2005 (Figure 2).[4]. In this small cross-section, exposure to the 2004-2006 monetary shock thus correlates well with the later origination of "real estate price contingent" loans. This is consistent with our risk-shifting interpretation.

Our model also predicts that NC should originate more loans in regions where real estate prices are more correlated with the return of its "legacy" assets. Again, the intuition is that NC was doomed to be bankrupt if its legacy assets' returns turned out to be low. NC shareholders were thus to benefit more from loans with payoffs highly correlated with its legacy assets' return. To boost this correlation should originate relatively more loans in regions where real estate prices correlate strongly with the returns of its legacy assets. In the data, we proxy for the returns on NC's legacy assets with a weighted-average real estate index, where the weight for each MSA is the share of NC's portfolio held in that MSA. We then define an MSA exposure to NC's legacy assets as the point estimate of a regression of real estate inflation at the MSA level on this proxy for NC's legacy assets' return and call it β^{NC}. As predicted by theory, this coefficient is a strong predictor of the geographic dispersion of loan origination.

[4]Origination of these loans was very small in 2003, both for New Century and the rest of the industry (Mayer et al, 2009; Demanynk and Van Hemert, 2009)

Finally, our model predicts that NC should originate more price-sensitive loans in regions whose prices are the most correlated with its legacy assets. This is a direct consequence of our first two predictions. NC survives if its legacy assets do well. This implies high real estate prices in regions with a high correlation with NC's legacy assets. This in turn implies that price-sensitive loans in these regions perform well. Thus, these loans in these regions have superior returns for shareholders who are only interested in returns contingent on survival. In the data, NC did originate more interest-only loans in regions with a higher β^{NC}.

Our paper makes three separate contributions. First, it belongs to the large corporate finance literature that documents the costs of financial distress. Cost of financial distress are invoked to explain, in theory and in practice, why companies hold so little debt (Almeida and Philippon, 2007, Ju, Parrino, Poteshman and Weisbach, 2005). The bulk of these costs are indirect (Andrade and Kaplan, 1998): financial distress distorts risk preferences of shareholders so much that they do not maximize firm value any more. Shareholders often tend to favor risk taking to gamble "for resurrection" (Esty, 1997, Gan, 2004, Fischer et al, 2011, for banks; Eisdorfer, 2008, and Becker and Stromberg, 2010, for non-financial firms). Career concern and agency consideration can also lead to excessively low level of risk-taking (Rauh, 2009, Gormley and Matsa, forthcoming). The main contribution of our paper with respect to this literature is to provide a precise characterization of the risk preferences of shareholders in financial distress and test it on "project-level" data. We propose a new way to characterize risk-shifting in project-level data based on the covariance of marginal projects with the firm's existing assets. Importantly, our modeling of risk-shifting does not imply that the projects financed under financial distress must have a negative NPV. Rather, we show that a firm in financial distress might forgo some projects in favor of lower NPV ones, when such projects have higher covariance with the firm's survival. This bias towards projects with high covariance is the "signature" of risk-shifting that we test in the data.

In studying a subprime mortgage originator, we also add to the growing literature on the US mortgage crisis. Our analysis provides a supply-side explanation for the massive origination of toxic loans in 2004-2006 (Demyanyk and Van Hemert, 2009, Mayer, Pence and Sherlund, 2010). We argue that originators became financially distressed as a result of their long-term investment in mortgages. This led them to issuing more "survival sensitive" loans, i.e. loans that would only payoff if real estate prices continued to go up. Barlevy and Fisher (2010) have proposed a "demand side" explanation where speculating borrowers in bubbly areas increased their demand for deferred amortization loans. In our tests, we show that both "demand side" (risk-taking households) and "supply side" (risk-shifting lenders) explanations are needed to explain the cross-regional issuance of deferred amortization loans. Our results also complement existing work on the perverse incentives of the originate-to distribute-model (e.g. Keys, Mukerjee, Seru and Vig, 2009).[5] Our paper sheds light on an unexplored part of these originators' activities: investment in their own loans.[6] It suggests that keeping "skin in the game" may be ex ante desirable, but may also distort incentives ex post. The narrative of the onset of the crisis that emerges from our analysis is thus different from a "looting view" of the crisis, whereby banks' executives, salesmen and traders engaged in risk-taking, negligence or other forms of rent extraction to the detriment of shareholders (Akerlof and Romer, 1993, LaPorta et al., 2003, Biais et al., 2010).

Third, our results suggest a new relationship between monetary policy and risk shifting. A popular view is that the Fed's persistent policy of low interest rates in the early 2000s fueled risk-taking by financial institutions "reaching for yield" (see for instance Rajan, 2005); Greenwood and Hanson (2011) provide evidence consistent with this view. As we show in Section 3, the 2004-2006 monetary tightening did severely weaken NC's balance sheet, and is likely to be an important factor behind the subsequent risk-taking that we document. The behavior of other originators, which we report on Figure 2, suggests that this consequence of monetary policy extended beyond the case of NC.

[5]Most papers in this literature focus on securitization (see also Pikorski, Seru and Vig, 2010, Purnanandam, 2010, Demiroglu and James, 2011). Others investigate the role of mortage brokers (Jiang, Nelson and Vytlacil, 2010, Berndt, Hollifield and Sandas, 2009).

[6]In the same vein, Acharya, Schnabl and Suarez (2010) show that securitization was not always riskless for the banks that securitized. In some vehicles, the issuing bank provided investors an explicit guarantee over their investment, in case underlying loans would default.

The remainder of the paper is organized as follows. Section 2 provides a simple project choice model of a levered financial institution that maximizes shareholder value. Section 3 shows that New Century was financially distressed in 2004. Section 4 describes the data. Section 5 tests the prediction of the risk shifting model. Section 6 concludes.

2. Investing in financial distress: Some theory

In this section, we present a simple model of project choice under distress and derive three testable predictions.

2.1. Basic insight

Consider the following model. There are three periods: 0, 1 and 2. At date 0, the firm finances its asset (the "legacy asset") with long-term debt D and interest $r + \tilde{\rho}$ that needs to be repaid at date 2. $\tilde{\rho}$ is a random variable (such as the LIBOR rate) and reflects the fact that NC borrowed at variable rates. The firm's asset delivers a positive random payoff $\tilde{R}^A$ at date 2. At date 1, $\tilde{\rho}$ is realized and the firm receives a dollar of cash from its existing assets. It can invest this dollar in either one of two small projects: project 1 or project 2. Each project $i = 1, 2$ will yield a random return $\tilde{R}_i$ at time 1. We assume that this reinvestment is marginal, i.e. the success or failure of this date-1 investment does not change the survival probability of the firm, which is entirely given by the initial project funded at date 0.[7]

We can define a survival dummy, $\tilde{S}(\rho) = \mathbb{I}_{\left\{\tilde{R}^A > (1+r+\rho)D\right\}}$, which is equal to 1 if the company does not default at date 2 and zero otherwise.[8] $p = E\tilde{S}$ is the date 0 probability that the company survives at time 1.

[7]This assumption shuts down the countervailing effect according to which, if interim projects are large enough to affect overall firm survival, shareholders may want to choose safe projects in order to increase the likelihood of survival. The "marginal project" assumption thus allows us to focus on risk-shifting. The risk-shifting effect still dominates provided that the size of the interim reinvestment is small enough relative to the size of the initial project.

[8]Note that this is the interim survival dummy as ρ here is the realization of the interest-rate shock $\tilde{\rho}$.

For a shareholder, the NPV of project i per dollar of investment is $E[\tilde{S}\tilde{R}_i]$. Project 1 is preferred over project 2 if and only if:

$$E[\tilde{R}_1] > E[\tilde{R}_2] + [cov(\tilde{R}_2, \tilde{S}/p) - cov(\tilde{R}_1, \tilde{S}/p)] \tag{1}$$

This decision rule does not coincide with NPV maximization. Indeed, in the absence of leverage (i.e. when $\tilde{S}$ is always equal to 1), shareholders compare the net present values of projects (here, $E[\tilde{R}_1]$ and $E[\tilde{R}_2]$) to decide on the marginal investment. But when the firm is levered, shareholders's preferences are tilted towards projects that tend to pay off in states where the company is afloat, even if their unconditional expected returns are lower. The higher the probability of default $(1-p)$, the stronger this bias toward high covariance projects is.

This simple model can be closed by simply assuming that the participation constraint of debtholders is binding at date 0 (i.e. financial markets are competitive at date 0). Because of our assumption that the interim investment is marginal, the interim risk-shifting behavior of the firm does not impact the price of debt. We defer the discussion on the price of debt when risk-shifting is no longer marginal to section 2.3.

$$p(1+\tilde{\rho}+\rho)D + (1-p)\mathbb{E}[\tilde{R}^A | \tilde{R}^A < (1+r+\rho)D] = D$$

Economic magnitude of covariance risk-shifting

To understand the economic magnitude of this distortion, let us consider the following numerical example. Assume that New Century expects house prices to collapse with probability 0.05.[9] Unless this happens, NC will stay in business, so $p = 0.95$. The firm can issue safe or risky mortgages. Let us assume that whatever the state of the real estate market, safe loans pay an interest rate of 6% with probability 0.97. With probability 0.03, they default and the

[9]This is a reasonable estimate. In a 2005 report, the investment bank Lehman Brothers was placing a probability 5% on a "meltdown" scenario, under which nationwide home prices would fall by 5% annually over the following 3 years (Gerardi et al, 2008).

return is -20% (recovery rate is 80% of loan value). Let us also assume that risky mortgages are more likely to default in case of real estate meltdown: in normal times, risky mortgages yield 8% with probability .97 and -20% with probability 0.03; in case of house price collapse, the risky loan defaults with probability 80%, with a recovery rate of 50%. In this example, a safe mortgage has an expected return of 5.2%; a risky mortgage has an expected return of 4.9%.

However, even when bankruptcy remains quite unlikely (5%), shareholders exhibit a strong preference for risky mortgages. From the viewpoint of NC's shareholders, the expected return on the risky mortgage is $0.95 \times (0.97 \times 8\% - 0.03 \times 20\%) = 6.8\%$, which is higher than the 5% (=5.2 $\times$ .95) the safe mortgage delivers. Hence, even if the firm is far from being insolvent, investment distortions can be quantitatively large.

2.2. Testable Implications

In this section, we explicit three testable predictions that are generated by the model. The results are derived formally in appendix, and we provide an intuitive exposition of them below.

We assume that at time 1, NC is faced with investment opportunities (mortgages) in different regions. We show that three characteristics of mortgages matter for NC when evaluating the opportunity to finance them or not: their expected return, their sensitivity to local real estate prices, and the correlation of local real estate prices to NC's legacy asset (this correlation varies across regions). Indeed, for a given expected return, loans that tend to fail only when NC is bankrupt are more attractive than those whose failure in uncorrelated with NC's financial health.

As we expose later, mortgages payoffs are more or less sensitive to local real estate prices depending on the contractual terms of the mortgage, so that the model delivers predictions on preferences by NC for certain types of contracts across regions. For now, we call "price-sensitive" mortgage contracts that deliver payoffs that are more sensitive to local real estate prices.

Assuming that the characteristics of the pool of loan applications that NC considers financing (expected return, sensitivity to local real estate prices and correlation of local prices with NC's legacy asset) are drawn independently, we derive the three following testable predictions:

Predictions *Following a tightening in monetary policy or a negative shock to the value of its legacy asset, NC originates:*

1. *more "price sensitive loans", i.e. loans whose payoffs are more sensitive to local real estate prices.*

2. *more loans in "asset sensitive regions", i.e. regions where real estate prices covary more with NC's legacy asset.*

3. *relatively more price-sensitive loans in asset sensitive regions.*

These three predictions are direct consequences of the preference for "survival contingent" projects spelled out previously. NC's bias toward projects with high covariance with its survival becomes stronger when default is more likely. The first prediction reflects the fact that NC's survival is highly correlated with aggregate real estate prices. Indeed, the loans held on balance sheet are more likely to default if real estate prices drop. Since local real estate prices are themselves highly correlated with aggregate prices, NC has a preference for price-sensitive loans, and this preference becomes stronger following an increase in the default probability. The second prediction reflects the fact that in a region where real estate prices covary more with the legacy asset, a mortgage also covaries more with the legacy asset, which makes it relatively more attractive to NC. Last, the third prediction reflects a complementarity between price-sensitivity of a loan to local real estate prices, and the covariance of those prices with NC's legacy asset. Indeed, the higher that covariance, the more rewarding the price-sensitivity of a loan is for NC's shareholders. This is because price-sensitive loans in high covariance regions act as survival-contingent projects and offer a way for New Century to achieve higher exposure on their legacy asset (i.e. the stock of loans held on balance sheet).

2.3. Discussion

We conclude this section by emphasizing the assumptions that are necessary for our risk-shifting results to hold. First, debt contracts are restricted to be non-contingent, long-term debt contract. It is well-known that convertible debt contracts can overcome risk-shifting incentives (see Biais and Casamatta (1999). Similarly, the threat of rollover associated with short-term debt can discipline shareholders in their risk-shifting behavior. Why NC did not use more complex securities (or hedging instruments against interest rate risk) is beyond the scope of this illustrative model. We simply start from the observation of NC's capital structure choice at date 0 and derive the interim behavior conditional on this observation. Second, the proof of the results relies on the firm receives interim free cash flows and using some of them to finance new projects. If NC was forced to raise at t=1 money from outside investors to fund all of the interim projects, the risk-shifting result would subsist only if the new debt was de facto senior (for instance due to shorter maturity) or pari passu (i.e. of similar seniority) to the pre-existing debt.[10] Third, the size of the interim projects are small relative to the size of the initial investment. Again, this allows us to focus on risk-shifting. Our modeling of risk-shifting does not imply that the projects financed under financial distress necessarily have a negative NPV. Rather, we show that a distressed firm, instead of picking its highest NPV projects, might prefer projects with lower NPV when

[10]However, if the firm faces at date 1 a supply of imperfectly rational investors willing to lend at a rate that is less than rationally elastic to risk, such as in Genaiolli,Schleifer and Vishny (2011), then it will exhibit a preference for projects with a high covariance with its existing asset, as in our model. Indeed, the value of risky projects for shareholders would be boosted by abnormally low financing rates, and, more interestingly, the best way for shareholders to exploit this bias is to invest in high covariance projects. The reason is that such projects deliver cash when the firm is afloat, thus benefiting shareholders (rather than boosting the recovery of ex-ante debt holders).

they exhibit a sufficiently high covariance with the firm's survival. The high covariance of marginal projects with the firm's existing assets is the "signature" of risk-shifting that we test in the data.

Finally, we emphasize that risk-shifting can be an equilibrium phenomenon even when ex-ante anticipated by debtholders. The origin of risk-shifting is that shareholders cannot commit to a risk-decision ex ante. Thus, even if priced at date-0, risk-shifting will nonetheless occur at date 1. Of course, this result strongly relies on the restrictions that we impose on the contract space: as already pointed out, shareholders could have been better off by using more complex contracts.

3. 2004: New Century in financial distress

This Section establishes that NC fell into financial distress in 2004, and provides anecdotal evidence of risk-shifting behavior.

3.1. New Century became a leveraged investor in 2003

Before 2003, all mortgages originated by NC were sold to third parties. These mortgages belonged to one of the following three categories:

- Standard fixed rate mortgages (FRMs): interest rate and monthly payments are fixed for the lifetime of the loan.

- Hybrid Adjustable Rate Mortgages (hybrid ARMs). Loan repayment starts with a 2 years "teaser" period during which monthly payments are fixed. Then, they follow the fluctutations of money market interest rates.

- Interest-Only ARMs: these are hybrid ARMs, with the added feature that the principal is not amortized during the 2 years teaser period. At the end of the teaser period, monthly payments are expected to increase significantly.

Like most of its competitors, NC pursued an aggressive growth strategy in the first half of the 2000s. Annual loan production increased from \$4.7bn in 2001 to \$35.1bn in 2005.[11] In 2003, NC started to keep a large amount of loans on its own balance sheet: loans held for investment went up from 0 in 2002 to \$4.7bn in 2003 and \$13.2bn in 2004. As a result, the firm experienced a significant increase in its gearing ratio, from 5 in 2002 to 11 in 2005. These long-term investments were financed through the issue of recourse collateralized bonds with variable interest rates. These bonds had a long duration. As of June 2004, over the \$9.1bn of outstanding bonds issued to finance loans held for investment, \$1.8bn (20%) were due in less than 1 year, \$2.5bn (27%) were due in 1 to 2 years, \$2.3bn (25%) were due in 3 to 4 years and \$2.4bn (26%) were due in more than 5 years (NC's 10-Q filing, June 2004). Interest payments on these bonds, while variable (a fixed margin over LIBOR), would not reflect an increase in risk-taking by the firm. As in the illustrative model presented in Section 2, this debt structure offered to NC's shareholders an opportunity to risk-shift.

3.2. Monetary policy tightening

The Federal Reserve increased its baseline interest rates from 1.5% in mid-2004 to 5.25% in mid-2006. As illustrated in Figure 3, this was partly anticipated by professional forecasters in the second half of 2003. This tightening is believed to be an important factor triggering the crisis (Mayer, Spence and Sherlund, 2009); we show here that it had a large adverse impact on NC's shareholders' wealth.

First, loans held for investment paid fixed rate, but were financed with variable rate bonds. In June 2004, NC held \$9.2bn of loans as investments. They were either FRMs or ARMs originated between mid-2003 and mid-2004 in their teaser period. As a result, these loans would pay fixed interest rates until at least mid-2005. These mortgages were financed through variable-rate bonds indexed on the one month LIBOR.[12] For \$9.2bn of loans, a linear increase in LIBOR by 4 percentage points over the next 2 years could be expected

[11] Source: 2005 10k filing.
[12] Source: 10-K filing, 2004

to reduce total cash flows by some \$360m.[13] This is a large effect: June 2004 book equity was only \$743m. This decrease in revenue is apparent from NC's statement of income. The interest income to interest expense ratio dropped from 3 in 2003 to 2.5 in 2004 and 1.8 in 2005. As explicitly acknowledged by the company, this confirms the low hedging position of NC on its interest rate exposure.[14]

Second, beyond the teaser period, ARMs held as investments would become riskier (Mayer, Spence and Sherlund, 2009). As interest rates would go up, monthly payments on ARMs were expected to increase, making some loans unaffordable and eventually become delinquent. In Figure 4, we report the average cumulative growth in monthly payment since origination for the 2003 ARM vintage. Monthly payments start rising in mid-2005, when these loans reset; by early 2007, repayments have increased by 25% since origination. This made ARMs unaffordable to some borrowers. We report in Figure 5 monthly delinquency rates (fraction of loans whose repayment is more than 60 days late) separately for FRMs and ARMs originated in 2003. While it remained in the vicinity of 5% for FRMs throughout the period, the delinquency rate of ARMs increased continuously from 8% in early 2005 to nearly 30% in the beginning of 2007.

Third, monetary tightening hurt growth opportunities. Prospective buyers would find it more difficult to borrow, as monthly payments would increase. In addition, higher interest rates on new loans would make refinancing (about three quarter of NC's loan applications in 2003) less attractive to borrowers already holding a fixed rate mortgage.[15]

[13] Assume that the interest rate increases linearly with time, by 4 percentage points over two years. Assume no discounting to simplify. Then, total loss due to interest increase is given by $\$9bn \times \int_0^2 (2t/100)dt = \$360m$.

[14] New Century reports some hedging of this interest rate exposure, using derivative contracts such as Euro Dollar futures or interest rate caps. However, positions were very limited in size. As of December 2004, the fair value of Eurodollar contracts was a mere \$26.1m and the fair value of interest caps was \$7.4 million, compared to an interest income was almost \$1bn as of December 2004.

[15] NC was well aware of the risk induced by a tightening of monetary policy. The 2005 10K file reports: *"Our profitability may be directly affected by changes in interest rates. The following are some of the risks we face related to an increase in interest rates. (1) When we securitize loans, the value of the residual interests we retain and the income we receive from the securitizations structured as financings are based primarily on LIBOR. This is because the interest on the underlying mortgage loans is based on fixed rates payable on the underlying loans for the first two or three years from origination while the holders of the applicable securities are generally paid based on an adjustable LIBOR-based yield. Therefore, an increase in LIBOR reduces the net income we receive from, and the value of, these mortgage loans and residual interests. (2)*

3.3. Regulation and competition

Competitive and regulatory pressure intensified in early 2004 for pure originate-to-distribute originators. Since the late 1990s, some states had adopted anti-predatory lending laws (APLs), whereby the purchasers of subprime loans were made liable for wrongdoing by the originators (Bostic et al, 2008). These laws made newly originated loans harder to sell to end-investors. In some states (e.g. Georgia and Massachussetts), APLs were so stringent that pure originators such as NC altogether stopped originating them. Furthermore, in August 2003, the Office of the Comptroller of the Currency decided to preempt state legislation in these matters, effectively shielding national banks and their subsidiaries from state APLs. NC explicitly acknowledges this as an important risk factor its 2004 10K : "Federally chartered banks and thrifts have a competitive advantage over us because the federal laws applicable to their operations can preempt some of the state and local lending laws applicable to our operations." Indeed, as shown by Ding et al. (2009), national banks did increase subprime lending after the OCC preemption: from 2004 to 2007, their share of subprime lending jumped from 9 to 20% in states with strong anti-predatory lending laws.

Our adjustable-rate mortgage loans have periodic and lifetime interest rate caps above which the interest rate on the loans may not rise. In the event of general interest rate increases, the rate of interest on these mortgage loans could be limited, while the rate payable on the senior certificates representing interests in a securitization trust into which these loans are sold may be uncapped. This would reduce the amount of cash we receive over the life of the loans in securitizations structured as financings and our residual interests, and could require us to reduce the carrying value of our residual interests. (3) An interest rate increase may harm our earnings by reducing the spread between the interest we receive on our mortgage loans and our funding costs.(4) A substantial and sustained increase in interest rates could harm our loan origination volume because refinancings of existing loans, including cash-out refinancings and interest rate-driven refinancings, would be less attractive and qualifying for a purchase loan may be more difficult. Lower origination volume may harm our earnings by reducing origination income, net interest income and gain on sale of loans. (5) During periods of rising interest rates, the value and profitability of our loans may be harmed between the date of origination or purchase until the date we sell or securitize the loans. (6) A substantial and sustained increase in interest rates could increase the delinquency and default rates on the adjustable-rate mortgage loans that we originate and hold because the borrowers monthly payments under such loans may increase beyond the borrowers ability to pay. High delinquencies or losses may decrease our cash flows or impair our ability to sell or securitize loans in the future, which could harm our results of operations, financial condition and business prospects."

3.4. Preliminary evidence of risk shifting

There are strong indications that the resulting loss in franchise value led New Century to risk-shift in 2004. Before turning to our formal tests, we document here two facts. Changes in the wording of annual reports in 2004 hint at a lowering of lending standards. In its 2003 10k file, NC describes how conservative it is when studying application for interest-only loans: *"We use a qualifying rate that is equal to the initial interest rate on the loan to determine the applicants ability to repay an adjustable-rate loan. We use a qualifying rate that is 3% higher than the start rate for determining the repayment ability of applicants for our interest-only product."* In other words, the company was more conservative with interest-only loans because it expected monthly repayments to increase. This contrasts with the 2004 10k file, which reports that *"for our interest-only mortgages, we generally use the initial interest-only payment for determining the borrowers repayment ability."* Such a reduction in lending standards is strongly consistent with risk-shifting.

The second piece of evidence relates to the payout policy: as mentioned in the introduction, COMPUSTAT quarterly shows that the dividend payout ratio increased dramatically from less than 5% in mid 2004 up to 90%(Figure 1). This happened because NC turned into a REIT in the last quarter of 2004. Corporate finance textbooks often invoke dividend issuances as a main mechanism for risk-shifting in distressed firms. For instance, Acharya et al (2010) have shown that banks significantly increased payouts between 2007 and 2009 despite widely anticipated credit losses, leading to a significant wealth transfer from creditors to shareholders. In NC's case, shifting to a REIT structure was a way of "milking the property" (Ross et al., 2010) in a tax-efficient manner. There are indications that the management was aware of the risk inherent to the REIT structure, i.e. set funds aside for "rainy days" (Muolo and Padilla, 2008).

4. Data

We describe here the three datasets we use for our tests. Detailed description of the sources and construction are deferred to Appendix A.

4.1. Loan characteristics sample

This dataset provides exhaustive information at the application level. For the purpose of this paper, we use the 192,973 loans originated by New Century in 2004. The variables used in the loan-level analysis are: loan-to-value ratio, household income, FICO score, property zip code, principal amount, an ARM dummy, an interest-only dummy and a full documentation dummy. For 25,732 of these 45,546 loans, we can retrieve monthly house prices at the MSA (Metropolitan State Area) level and generate a "Low growth" dummy, equal to 1 if house prices grow by less than 10% in the 24 months following the loan's origination (end of the teaser period). We also define four dummies for each quartile of the distribution of real estate price growth in the 24 months following origination. These quartiles are defined in the sample of MSAs to avoid composition effects.

We report descriptive statistics on loan characteristics in Table 1, Panel A. 56% of all loans do not have full documentation. This raises the concern that characteristics of these loans may not be reliable, so we will check that our results hold for the subset of full documentation loans. The average loan-to-value ratio is 85%. The average household in the sample has an income of about $6,500 per month, compared to a nationwide average $3,700.[16] The average FICO is 623, close to the 620 limit below which borrowers are usually considered subprime. New Century originated, in 2004, 37% of FRMs, 50% of hybrid ARMs and 13% of interest-only ARMs. Mayer et al. (2009) document on a large sample of securitized loans originated in 2004 a proportion of 11% of interest-only loans and 21% of FRMs. NC's origination policy was not an outlier in the industry.

[16]Source: Census bureau. http://www.census.gov/hhes/www/income/data/statemedian/index.html

4.2. Loan performance sample

NC's servicing data contains exhaustive information on the loans serviced by NC. As of December 31, 2004, the balance of NC loan servicing portfolio was \$24.4 billion, consisting of \$11.6 billion in mortgage loans held for investment, \$3.9 billion in mortgage loans held for sale, \$7.7 billion in interim servicing, and \$1.2 billion in servicing rights owned. Interim servicing represents loans sold to whole loan investors that NC has agreed to service temporarily pending their transfer. Servicing rights owned are loans sold to whole loan investors for which NC retained the servicing rights. Thus, 47% of the loans in NC's servicing portfolio are serviced on a temporary basis before they are sold to other investors. The repayment history of these loans is thus limited to a few months following origination. To focus on the set of loans for which we observe the entire servicing history, we keep only the loans for which we observe more than 12 months of servicing data. This constitues a panel of monthly repayments for 45,546 of the 193,973 loans originated in 2004. Among these loans, 91% are loans held for investment. Our analysis of NC's loans performance is thus representative of the set of loans that were held on NC's balance sheet.

For each loan i, we collect, in month t, the following variables: (i) the cumulative growth in due monthly repayment since origination and t (ii) a dummy variable equal to 1 if the borrower is, in month t, more than 60 days late on payments (a standard measure of delinquency), and (iii) a dummy equal to one if the loan is refinanced during month t. NC does not directly reports refinancing, so we label refinanced at date t a loan that (1) has a remaining balance that goes down to 0 in month t (2) exits the sample in month $t+1$ (3) is not delinquent in month $t-1$. For the 45,546 loans with servicing data, we also construct a dummy equal to 1 if the loan ever becomes delinquent before February 2007. Descriptive statistics on this variable can be found in Table 1, Panel A. 15% of the loans originated in 2004 will be delinquent by February 2007.

The fact that we do not measure the performance of all loans originated by NC may raise a representativeness concern. In Table 1, Panel B, we check the observable differences between the loans that appear and the loans that do not appear in our performance sample. These loans do not differ in terms of documentation, borrower's creditworthiness, or borrower's income. There is a statistically significant difference in leverage, but the economic magnitude is small (85 versus 86% loan to value ratio). Loan composition differs more: Loans with performance data are 9 ppt more likely to be ARMs, and 5 ppt more likely to have an interest-only period. We will come back to this point in section 3.4.

Table 2 reports summary statistics on the 2004 vintage performance, by loan type (FRM, ARM and Interest-only). We focus on 4 cross sections: June 2005, December 2005, June 2006, and December 2006. The number of observations falls over time as loans are refinanced or default and therefore exit the sample. Panel A shows the average monthly payment growth since origination. Naturally, it is zero for FRMs. For variable-rates mortgages, the monetary tightening started in July 2004 leads to an increase in monthly payments after June 2006, i.e. after the expiration of the teaser period. In December 2006, monthly payments on ARMs have grown, since origination, by about 6%. For interest-only loans, this growth is much larger at 13%. This simply reflects the fact that the end of the teaser period for these loans corresponds to the beginning of principal amortization. This "payment shock" leads to an increase in refinancing, as borrowers who have earned enough home equity can shift to lower interest rate loans. This can be seen in Panel B of Table 2. For both ARMs and FRMs, the refinancing rate tends to decrease over time, while it doubles, from 6% ot 12% for interest-only loans. Interest-only loans thus experience the strongest payment shock, as well as the largest increase in refinancing rate. As shown in Panel C, interest-only loans also experience the largest increase in delinquency rates, as some borrowers will find themselves unable to refinance their interest-only loans following the first reset.

4.3. Geographic data

We construct a sample of loan origination, aggregated at the MSA level. This sample is made of 352 MSAs. For each of these MSAs, we calculate the log of 1 plus the dollar value of all NC loans originated both in 2003 and 2004, as well as the log of 1 plus the total amount of interest-only loans originated per MSA. We also use the 2000 census to compute, per MSA: (i) the fraction of inhabitants that did not reach the 9th grade of high school (ii) the fraction of households below the poverty line and (iii) the average house price to income ratio in 2000.

We report summary statistics for these variables in Table 3. The average log total origination in 2004 is 16.13, which corresponds to about \$10m per MSA. The share of households below the poverty line is 15%, slightly above national average (13%). The 2000 price to income ratio is on average 3.6.

Central to our hypothesis testing is β_s^{NC} (see Section 2), which measures the sensitivity of real estate prices at the MSA level to the returns of NC's "legacy" assets. Let $g_{s,t}$ be the real estate price quarterly growth rate in MSA s in month t. Define R_t^A as:

$$R_t^A = \sum_s w_s . g_{s,t} \tag{2}$$

where w_s is the share of MSA s in the portfolio of loans originated and held by NC in 2003. R_t^A is our proxy for NC's legacy assets returns in month t. It corresponds to the average real estate inflation of the underlying houses held on NC's balance sheet. β_s^{NC} is the linear regression coefficient of $R_{s,t}^A$ on g_t over the 1970-2003 period. It captures the extent to which real estate prices in a given MSA s correlates with real estate prices of loans already in NC's portfolio. As Table 3 shows, the cross MSA average β_s^{NC} is 0.89.

5. Evidence of risk-shifting

This Section tests the three predictions of the canonical risk-shifting model described in Section 2.

5.1. The shift toward home price-sensitive loans

In the first quarter of 2004, New Century started massively originating interest-only ARMs. We show in this Section that the return on these loans is, in effect, more sensitive to local real estate prices than the typical loans NC would originate before 2004. This is in line with our Prediction 1.

In Figure 6, we first report the evolution of the fraction of interest-only loans originated. Until February 2004, 99% of NC's loan production was made of FRMs and ARMs. Then, the share of interest-only loans starts to take off and reaches nearly 40% of originations in mid-2005. Then, these loans are progressively substituted for by "balloon loans". These loans, like interest-only loans, have a deferred amortization schedule: their maturity is 30 years, but amortization is spread over 40. Hence, a sizeable fraction of the principal has to be repaid at maturity. Together, interest-only and balloon ARMs account for about 60% of total loan production in January 2007. Because we need to observe loans at least 24 months after their issue (end of the teaser period), we focus on the 2004 vintage and thus leave balloon loans out of the subsequent analysis.

Interest-only loans are by design more sensitive to real estate prices than other traditional loans. Interest-only loans were not supposed to be frequently held to maturity, but only until the end of the teaser period. At this stage, refinancing was most often necessary because monthly payments would increase dramatically, as the borrower began to repay the principal. But refinancing required an increase in real estate prices: if in the first 24 months the borrower had built enough home equity, his wealth could be used to borrow at a lower loan-to-value and therefore at a lower rate.[17] In a weak real estate market, refinancing with better terms becomes impossible, and some borrowers have no other choice but to default. In short, originating these loans was a bet on the appreciation of real estate prices.

[17] An alternative was to use the capital gains to increase the amount of principal in exchange for a lower interest rate. This practice is referred to in the industry as the purchase of "lender's points".

We now document empirically this ex-post behavior of interest-only loans held originated by NC in 2004. First, the payment shock occurring at the end of the teaser period is very large compared to standard ARMs. Figure 7 reports, for both ARMs and interest-only loans, the average cumulative increase in monthly payment since origination, around the end of the teaser period. For interest-only borrowers in 2004, monthly payments increase by more than 50% after the end of the teaser period relative to the more modest 22% increase for ARMs.[18] Second, many borrowers did refinance their interest-only loans to avoid this large payment shock. In Figure 8, we display, by loan type, the average refinancing rate each month around the end of the teaser period. Prior to the reset, the refinancing rate is around 4% per month for each type of loan. Following reset[19] the refinancing rate for interest-only loans jumps to 20%. By comparison, ARMs experience a smaller increase in refinancing rate (up to 10%). The refinancing rate of FRMs remains around 4%. Third, interest-only borrowers with smaller capital gains find it harder to refinance at the end of the reset period and are thus more likely to become delinquent. Three months around the end of the teaser period, we calculate the difference in delinquency rates between loans originated in slow growing MSAs (top quartile of real estate price growth 24 months after origination) and fast growing MSAs (bottom quartile). Figure 9 plots this excess delinquency rates separately for ARMs and interest-only loans. While the excess delinquency rate is essentially flat for ARMs, it increases by 12 percentage points for interest-only loans in the three months following the teaser period. This is prima-facie evidence that interest-only loans were more sensitive to real estate prices than the typical products sold by NC before 2004.

Formally, we test prediction 1 with the following probit regression:

$$EVERDEL_i = a + bLG_i + b_{ARM}ARM_i \times LG_i + b_{IO}IO_i \times LG_i + controls_i + \epsilon_i \qquad (3)$$

[18]That ARMs also experience an increase in monthly repayment is natural since the short-term rates did increase substantially between 2004 and 2006 (see Section 3.)

[19]The reset on FRMs is fictitiously set at 24 months after origination.

where $EVERDEL_i$ is an indicator variable equal to 1 if loan i is at least once delinquent after February 2004 This regression is run on the exhaustive sample of loans originated in 2004. $LG_i = 1$ if the loan is originated in an MSA where real estate prices grow by less than 10% in the 24 months following the loan's origination. $ARM_i = 1$ if the loan is an ARM, and $IO_i = 1$ if it is interest-only. The regression controls for month-of-origination fixed effects as well as loans and borrowers characteristics such as: Loan-to-value, FICO, Debt /Income, Log(Loan Amount), unemployment in the MSA where the loan is originated and a secondary house dummy. The marginal effects, reported in Table 4, show that interest-only loans exhibit a significantly higher sensitivity of unconditional default to real estate prices relative to ARMs and FRMs. Origination in a slow price growth area increases the unconditional probability of default of interest-only loans by 7.1ppt relative to FRMs (Column 1). The difference in sensitivity between IO and FRMs or ARMs is significant at the 1% confidence level. This effect is economically very large, since the average ever delinquency probability of interest-only loans is 12.8%. Column 2 shows that controlling for loans and borrowers characteristics does not change our estimate. Column 3 estimates equation 3 on the sample of full doc loans and find similar results. Columns 4-6 repeat the previous estimations, but use the four quartile dummies of real estate price growth instead of the slow price growth dummy. These results are monotonous in real estate price appreciation.

5.2. The shift toward asset sensitive regions

We test prediction 2 – that NC invested more in regions with a high covariance with its legacy assets' returns – with the following MSA-level OLS regression:

$$\log(\text{total \$ issues in 2004})_s = a + b \times \beta_s^{NC} + controls_s + \epsilon_s \tag{4}$$

where $\log(\text{total \$ issues in 2004})_s$ is the log of 1 plus total loan amount issued in MSA s by NC in 2004. β_s^{NC} measures the historical correlation between real estate prices in MSA s and a proxy for the returns on the portfolio of loans held by NC in 2003 (see Section 4.3 for the construction of β^{NC} and how it relates to the model of Section 2). We also control for potential determinants of the geographic dispersion of loans originated by NC. Most importantly, the log of 2003 originations in MSA s captures existing biases of NC's origination policy toward particular MSAs. The share of low income and low education households in the MSA should capture the propensity to issue subprime loans in MSAs with low financial literacy.

In 2004, New Century originated significantly more loans in MSAs with a higher β_s^{NC} (Table 5). The effect of β^{NC} on loan origination is statistically significant at the 1% level in this MSA-level sample. In our multivariate specification (columns 2-3), an increase in β_s^{NC} by 0.28 (one sample s.d.) leads to an increase in log origination in 2004 by 0.5, which corresponds to about 30% of the sample s.d. of this variable. Finally, we exclude in column 4 all the MSAs located in California, Florida and Texas, which account for a disproportionate share of originations and could be argued to be outliers. The estimates are left unchanged.

5.3. More price-sensitive loans in asset-sensitive regions

We test prediction 3 – that NC's propensity to issue interest-only loans was higher in high β^{NC} MSAs – with the following loan-type/MSA level OLS regression:

$$\%\ \text{issues}_s^k = a^k + b^k \times \beta_s^{NC} + controls_s + \epsilon_s \tag{5}$$

where $\%\ \text{issues}_s^k$ is the fraction of loans of type k issued in MSA s. The control variables are identical to those used for Table 5.

Columns 1-4 of Table 6 confirm that NC originated a larger fraction of interest-only loans in high β_s^{NC} regions. The effect is statistically and economically significant. In column 1, the estimate suggests that a 0.28 increase in β_s^{NC} (one s.d.) is typically accompanied by a 5 ppt increase in the share of interest-only loans (about half of the sample s.d.). This effect is barely affected by the financial literacy controls (columns 2). In column 3, we remove MSAs located in California, Florida and Texas. While the point estimate decreases, the effect of β_s^{NC} on interest-only origination remains statistically significant and of the same order of magnitude. Finally, in column 4, we estimate equation 5 using quartiles of β_s^{NC} instead of β_s^{NC}. The effect of β_s^{NC} is monotonous, which confirms that the results are not driven by a few outlier MSAs. Columns 6-9 show that the opposite effect happens for the fraction of FRMs. Consistently with prediction 3, the fraction of price-insensitive loans should decrease, in particular in asset-sensitive regions.

In columns 5 and 10, we control for alternative "demand stories" whereby interest-only loans are issued in response to demand by cash-strapped or speculating households (Barlevy and Fisher, 2010). To do this, we include the ratio of home price to income in 2000. In cities where this is high, we expect speculation to be stronger; we also expect that the increase in interest rate hurts households' repayment abilities the most, leading to a surge in demand for IO loans. In both stories, IO loans would be driven by demand and not by the risk shifting hypothesis we seek to put forward here. Columns 5 and 10 show that our hypothesis resists the inclusion of the price-to-income ratio. The magnitude of the coefficient does not change significantly. Consistent with Barlevy and Fisher (2010), the price-to-income ratio is also correlated with the propensity to issue IO loans: both demand and supply side stories seem to be at work in the data.

6. Concluding remarks

This paper provides forensic evidence on the risk-shifting behavior of a large subprime mortgage originator. The sharp increase in interest rate in 2004 destroyed a significant fraction of New Century's shareholder value. In reaction, New Century drastically modified its business model. It started originating loans with a larger exposure to real estate price risk – interest-only loans. It changed the geography of its operations – selling more and more of these new loans in cities with real estate prices correlated with the returns on its legacy assets. This new business strategy is consistent with a model of a risk-shifting by a financially distressed company who starts taking long bets on its own survival. We propose a new way to characterize risk-shifting in project-level data based on the covariance of marginal projects with the firm's existing assets.

Our paper may have implications for monetary policy. In response to a heating real estate market, policy makers thought in 2004 that increasing interest rates was the appropriate response. Our paper suggests this decision had unintended consequences: by pushing mortgage originators closer to financial distress, the monetary tightening led mortgage originators to increase risk-taking. In the case of New Century – and probably of other originators who held large amounts of loans on their balance sheet – risk-taking meant enhancing exposure to real estate price risk. This may well have fuelled the real estate bubble and eventually accentuate the burst of this bubble.

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7. Tables

Table 1: Summary statistics of loan characteristics

Panel A: Summary statistics for the full sample						
	Obs.	Mean	Median	Std. Dev.	25^{th}	75^{th}
Full documentation	192,973	0.56	1	0.50	0	1
Loan to Value	192,973	0.85	.90	0.14	.79	1
Log(monthly income)	192,891	8.6	8.6	0.53	8.27	8.94
FICO score	192,961	623	624	61	580	663
ARM	192,972	0.63	1	0.48	0	1
Interest only ARM	192,973	0.13	0	0.34	0	1
Secondary home	192,973	.056	0	.23	0	1
Log(Loan Amount)	192,973	11.83	11.87	.715	11.35	12.38
Debt/Income	163,089	3.64	3.3	1.87	2.42	4.37
Ever delinquent	45,546	0.15	0	0.36	0	1
Unemployment	44,569	.061	.056	.021	.051	.065
Low growth MSA	25,732	0.26	0	0.44	0	1

Panel B: Loans with and without performance data Difference of means tests			
	No perf. data	With perf. data	t-stat.
Full documentation	0.56	0.56	0.18
Loan to Value	0.85	0.86	6.3***
Log(monthly income)	8.6	8.6	3.8***
FICO score	623	623	.83
ARM	0.61	0.70	35.4***
Interest only ARM	0.12	0.17	26.7***

Note: 192,973 loans originated in 2004 by New Century. "Full documentation" is a dummy equal to 1 if the borrower provided full documentation. "Loan to value" is equal to the sum of mortgage principals issued by New Century to property value as appraised by New Century. "Log(monthly income)" is the logarithm of household combined monthly income. "FICO score" is the borrower's credit score, reported by NC's internal records but calculated by an independent firm; more creditworthy have a high FICO; 620 is the threshold below which borrowers usually are considered subprime. "ARM" is a dummy equal to 1 if the loan has variable interest rate. "Interest only ARM" is equal to 1 if the loan has flexible interest rate and starts with a two year period during which the loan principal is not repaid. "Secondary Home" is equal to 1 if the house is not the primary residence of the borrower. "Log(Loan Amount)" is the log of the amount of the loan. "Debt/Income" is the ratio of total debt over annual income. "Ever deliquent" equals to 1 if the borrower becomes, at some point in its history, more than 60 days late in its monthly payment. "Low growth MSA"=1 if cumulative home price growth in the MSA, 24 month after loan origination, is below 10%. "Unemployment" is the unemployment ratio at the zipcode level. Panel A provides summary statistics for the full sample. We then break down the sample into loans for which performance data are available (loans likely to be kept by NC on its balance sheet), and loans for which NC did not monitor performance (loans likely to be resold). Panel B reports means and difference tests of characteristics for both these samples. *,**,*** mean stastically different from zero at 10,5 and 1 %.

Table 2: Summary statistics of loan performance & monthly payment growth

By Loan Type:	FRM	ARM	Interest-Only ARM
Panel A: Mean cumulative growth in payment			
June 2005	0.00	0.00	0.01
	(15,432)	(28,287)	(8,768)
December 2005	0.00	0.00	0.01
	(11,316)	(20,953)	(6,489)
June 2006	0.00	0.01	0.03
	(9,452)	(15,752)	(4,911)
December 2006	0.00	0.06	0.13
	(7,866)	(10,658)	(3,107)
Panel B: Mean refinancing rate			
June 2005	0.07	0.07	0.06
	(15,432)	(28,288)	(8,768)
December 2005	0.04	0.06	0.06
	(11,316)	(20,953)	(6,489)
June 2006	0.03	0.05	0.07
	(9,492)	(15,752)	(4,911)
December 2006	0.03	0.07	0.12
	(7,866)	(10,658)	(3,107)
Panel C: Mean delinquency rate			
June 2005	0.02	0.04	0.02
	(15,432)	(28,288)	(8,768)
December 2005	0.05	0.09	0.04
	(11,316)	(20,953)	(6,489)
June 2006	0.06	0.10	0.05
	(9,492)	(15,752)	(4,911)
December 2006	0.07	0.16	0.11
	(7,866)	(10,658)	(3,107)

Note: Monthly performance data of loans issued in 2004 by New Century, and whose monthly repayments are monitored by the issuer. We only keep monthly repayments starting 13 months after origination. We report in this table summary statistics for 4 cross sections only: June 2005, December 2005, Panel A reports the average cumulative payment growth, since 13 months after origination, quarter by quarter, and by type of loan. Panel B reports the mean monthly refinancing rate (fraction of non-delinquent loans exiting the data) and panel C the mean monthly delinquency rate (fraction of loans whose payment is more than 60 days late). The number between brackets is the number of observations used to compute the mean. Plain figures are averages; number of observations are between brackets.

Table 3: Summary statistics of MSA-level lending activity

	Obs.	Mean	Median	Std. Dev.	25^{th}	75^{th}
Log of origination 2004	352	16.13	15.97	1.64	14.85	17.20
Log of origination 2003	351	15.55	15.35	1.47	14.50	16.54
Fraction of IO loans 2004	352	.091	.056	.108	.007	.124
Fraction of FRM loans 2004	352	.302	.279	.139	.206	.376
β_s^{NC} of city	352	.89	.87	.28	.70	1.07
Share of low income HHs in city, 2000 (in %)	352	.15	.15	.02	.14	.16
Share of low education HHs in city, 2000 (in %)	352	.239	.236	.02	.231	.242
Home price to income ratio, 2000	352	3.56	2.95	1.82	2.34	4.20

Note: MSA-level data. "Log of origination, 2004" measures the log amount of loans originated in each of the 352 MSAs covered by New Century in 2004 for which $\beta^N C$ is available. "Fraction of IO loans 2004" measures the fraction of interest-only mortgages originated by New Century, in each MSA in 2004. "Fraction of FRM loans 2004" measures the fraction of Fixed-Rate mortgages originated by New Century, in each MSA in 2004. "β_s^{NC} of city" is given, for each MSA s, by $cov(R_{s,t}^{HOME}, R_t^{NC})/var(R_t^{NC})$. $R_{s,t}^{HOME}$ is the growth rate of quarterly home prices in MSA s. R_t^{NC} is the average of $R_{s,t}^{HOME}$ across MSAs, weighted by the loan amounts issued by NC in 2003. Hence, β_s^{NC} is the regression coefficient of local home price growth on the average home price growth of properties in NC's production. The last three variables come from the 2000 census 5% extract. "Share of low income" is the fraction of households below poverty line (POVERTY variable in the 2000 Census). "Share of low education" is the fraction of households in the MSA who have completed at most 8th grade. "Home Price to income" is the average ratio of owner-occupied home prices to household income, taken at the MSA level.

Table 4: The price sensitivity of delinquency rates

	Probability of ever being delinquent					
	All	All	Full doc only	All	All	Full doc only
ARM × Slow growth	-.00023	.0033	-.012			
	(-.014)	(.24)	(-.95)			
I/O × Slow growth	.071***	.083***	.076**			
	(2.7)	(3.2)	(2.4)			
ARM × Q2				.00097	.0091	.028
				(.045)	(.52)	(1.4)
ARM × Q3				-.0033	.007	.018
				(-.16)	(.37)	(.91)
ARM × Q4				.017	.011	.037**
				(.85)	(.67)	(2.1)
I/O × Q2				-.011	-.011	-.0061
				(-.4)	(-.43)	(-.23)
I/O × Q3				-.055***	-.039**	-.04
				(-2.8)	(-2)	(-1.6)
I/O × Q4				-.039**	-.052***	-.048**
				(-2)	(-3.2)	(-2.4)
ARM	.057***	.031***	.036***	.053***	.024*	.011
	(7.5)	(3.8)	(4.3)	(3.2)	(1.9)	(.87)
I/O	-.038**	-.0012	.013	.02	.06***	.073***
	(-2.6)	(-.086)	(.8)	(1.2)	(2.7)	(2.8)
Slow growth	.092***	.068***	.064***			
	(3.9)	(3.7)	(3.6)			
Q2				-.028	-.031*	-.039**
				(-1.3)	(-1.7)	(-2.4)
Q3				-.06***	-.051***	-.047***
				(-3)	(-3.3)	(-3.1)
Q4				-.14***	-.11***	-.11***
				(-7.2)	(-7.3)	(-7.8)
Loan to value		.0031***	.0029***		.0031***	.0029***
		(9.6)	(8)		(11)	(8.4)
FICO		-.0013***	-.0014***		-.0012***	-.0013***
		(-17)	(-13)		(-21)	(-16)
Debt /Income		.0014	.0054**		.0025	.0063***
		(.75)	(2.4)		(1.6)	(3.2)
Log(Loan Amount)		-.025***	-.043***		-.022***	-.039***
		(-4.1)	(-6.2)		(-3.6)	(-5.9)
Unemployment		.11	.24		.22	.37*
		(.48)	(.86)		(1.2)	(1.9)
Secondary home		.037**	.014		.031**	.0078
		(2.5)	(.88)		(2.2)	(.53)
Month of origination FE	YES	YES	YES	YES	YES	YES
Observations	25,732	20,999	12,562	25,732	20,999	12,562

Source: Marginal effects from a probit regression. Loans characteristics data, 2004 vintage. We consider loans present in the database for more than 12 months and define "Ever Delinquent" is a dummy equal to one if the loan is at least once more than 60 days delinquent. We regress "Ever Delinquent" on measures of price growth interacted with loan type (Interest Only, ARM or FRM). The reference for loan type is FRM. Columns 1-3 use "Slow growth", a dummy equal to 1 if local home price growth is lower than 10% over the 24 months following origination. Columns 4-6 use quartile dummies "Qi". Qi=1 is the first 24 months home price growth of loan i belongs to quartile number i. Columns 3 and 6 restrict the sample to full doc loans only. Results are clustered at the MSA level. t-statistics are in brackets. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

Table 5: MSA level amount of loans originated in 2004

	MSA level log of origination				
	Whole sample				Non-core states
β	2***	.38***	.37***		.38***
	(7)	(3.6)	(3.4)		(2.8)
β Q2				-.012	
				(-.13)	
β Q3				.073	
				(.82)	
β Q4				.28***	
				(3.1)	
log(origination 2003)		1***	1***	1***	.98***
		(30)	(29)	(29)	(20)
Low income			-.42	-.61	-1.1
			(-.28)	(-.41)	(-.52)
Low education			-.27	-.25	-9.6
			(-.19)	(-.17)	(-1.6)
Constant	14***	-.081	.061	.33	3
	(58)	(-.14)	(.082)	(.42)	(1.4)
Observations	352	351	351	351	287
R^2	.11	.88	.88	.88	.84

Notes: OLS estimation. MSA-level data. We regress the log of total 2004 $ origination by MSA on the MSA's β, the MSA fraction of low income househoulds, the MSA fraction of low education households, and the log total 2003 $ origination in 2003 in the MSA. Column 1 includes no control Robust standard errors. t-statistics are in brackets. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

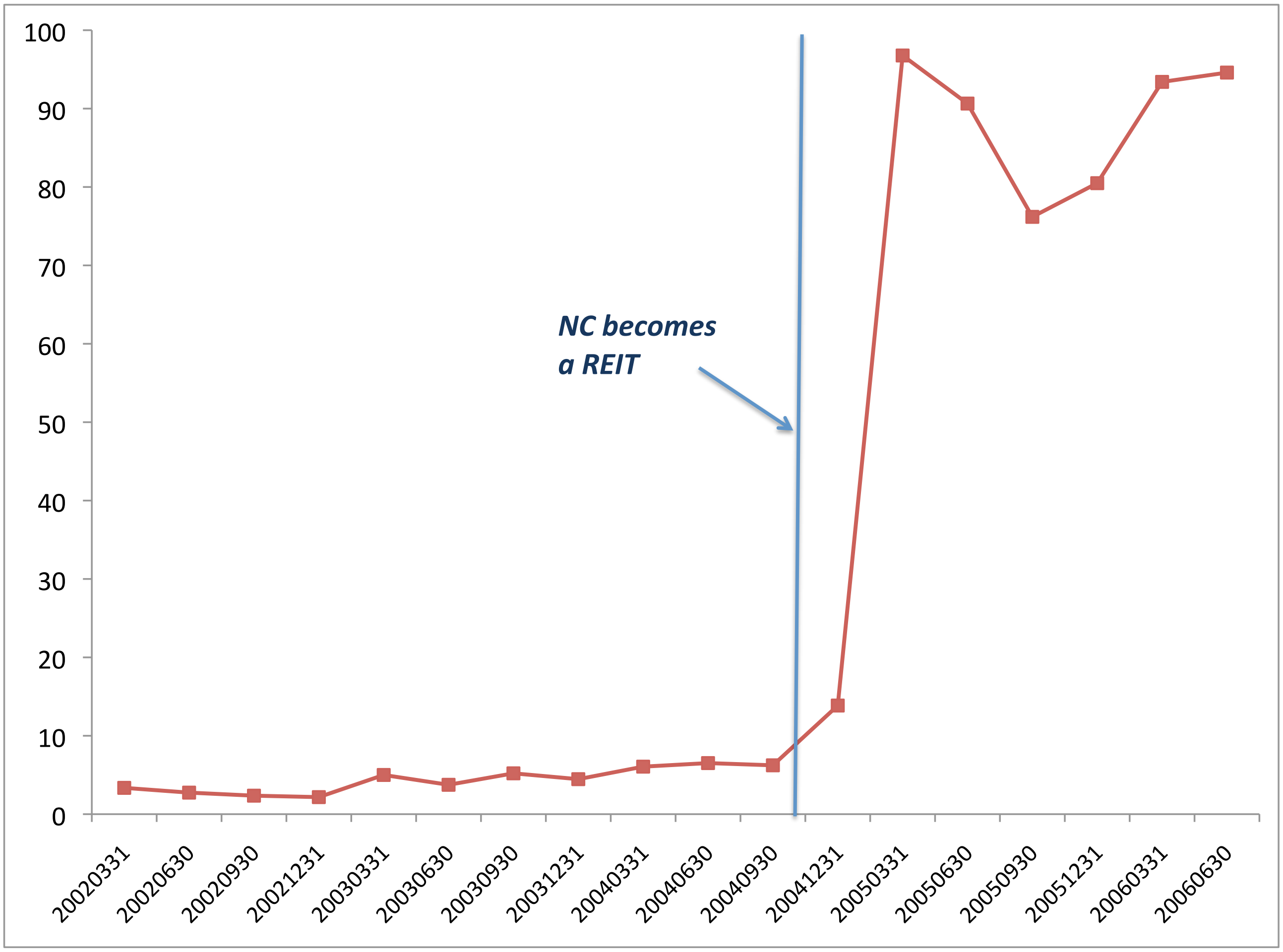
Table 6: MSA fraction of Interest-Only and Fixed-Rate mortgages originated in 2004

	Fraction of IO loans					Fraction of FRM loans				
			Non-Core States					Non-Core States		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
β	.17***	.18***	.11***		.08***	-.2***	-.19***	-.12***		-.17***
	(8.4)	(8.3)	(6.2)		(5.2)	(-7.4)	(-7.3)	(-4.5)		(-5.7)
Log(origination 2003)	.024***	.024***	.019***	.026***	.0091***	.0035	.0015	-.0025	.0005	.0034
	(7.3)	(7.3)	(5.2)	(7.4)	(2.8)	(.76)	(.32)	(-.5)	(.11)	(.64)
Low Income		.072	.26	-.015	-.23		-.3	-.41	-.14	-.26
		(.2)	(.67)	(-.039)	(-.7)		(-.77)	(-.79)	(-.37)	(-.65)
Low Education		.055	-.28	.1	.12		1.2***	-.34	.98***	1.2***
		(.18)	(-.51)	(.3)	(.49)		(3.7)	(-.45)	(3)	(3.7)
β Q2				.034***					-.072***	
				(3.5)					(-3.5)	
β Q3				.044***					-.11***	
				(4.3)					(-4.9)	
β Q4				.12***					-.14***	
				(7.9)					(-7.1)	
Price/Income$_2$000					.03***					-.0038
					(8.2)					(-.81)
Observations	351	351	287	351	351	351	351	287	351	351
R^2	.39	.39	.22	.36	.52	.14	.17	.065	.17	.17

Notes: OLS estimation. MSA-level data. This table regresses the fraction of 2004 origination of Interest-Only loans (columns 1 to 5) and Fixed-Rate loans (columns 6 to 10) by MSA on the MSA β, the MSA fraction of low income households, the MSA fraction of low education households, the log amount originated by NC in 2003 by MSA and the median Price to Income ratio in the MSA in 2000. Robust standard errors. t-statistics are in parenthesis. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

8. Figures

Figure 1: Dividend Payout Ratio of New Century



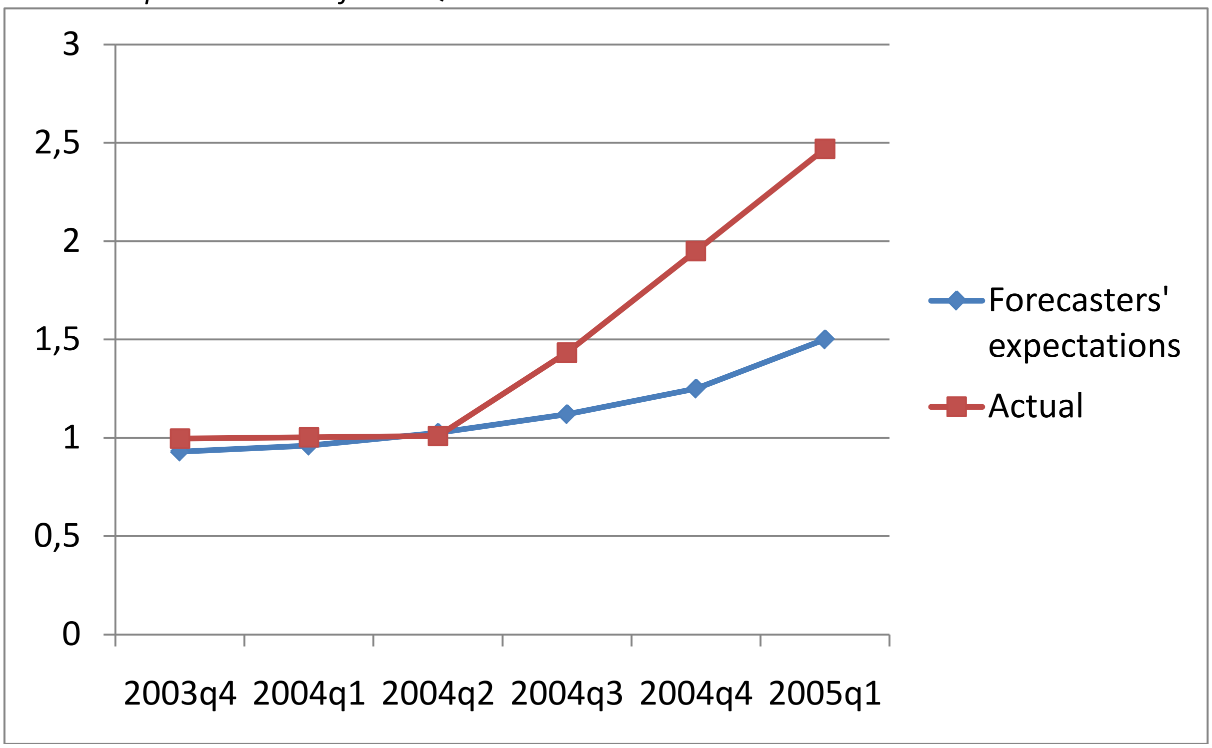
Source: COMPUSTAT quarterly data. Each quarter, we divide cash dividends by net income.

Figure 2: Loans held for investment in 2003 and 2005 issue of deferred amortization loans

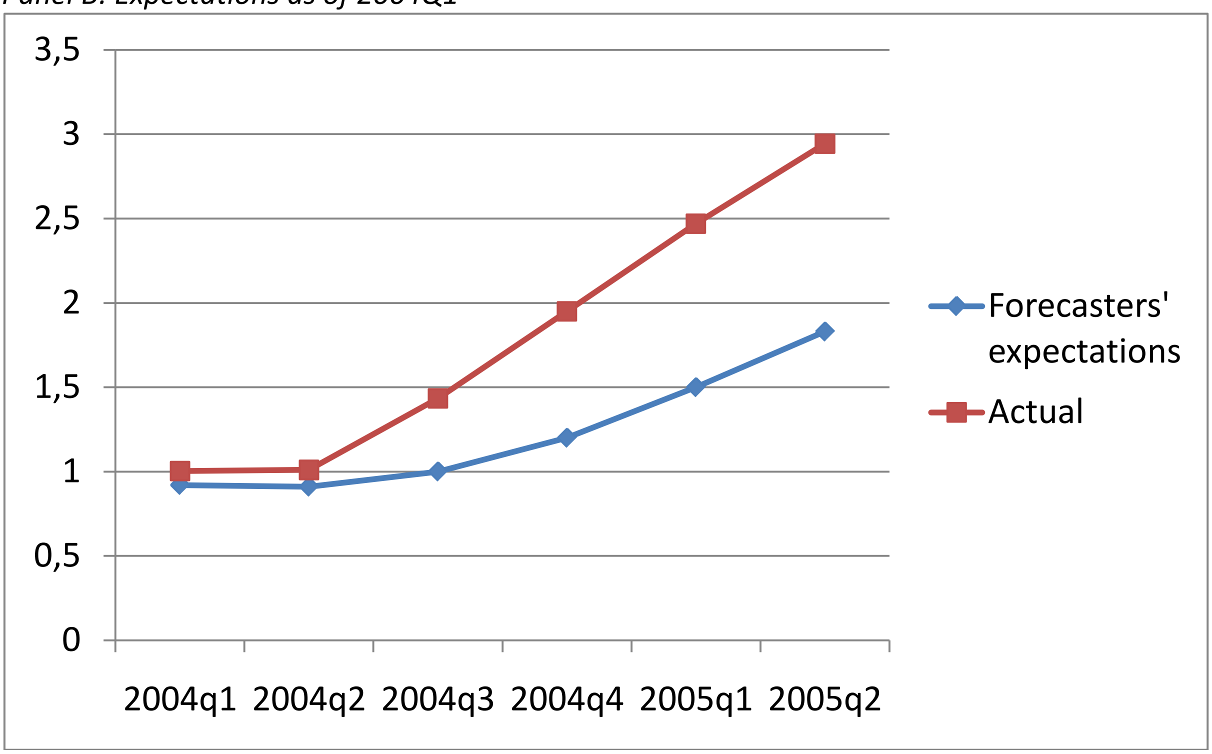
Source: Cross-section of subprime mortgage originators (10k filings). Note: We looked for all publically traded companies who are pure or quasi-pure plays in the following industries: sic = 6798 (real estate investment trusts) and sic = 6162 (mortgage bankers & loan correspondents). We retrieved from their 10K filings total originations and interest-only origination (when this information is available). This figure reports the fraction of total (dollar) origination accounted for by issuance of deferred amortization loans in 2005 as a function of Loans held for investment as a fraction of total assets at the end of 2003.

Figure 3: Actual and expected shift in monetary policy

Panel A: Expectations as of 2003Q4

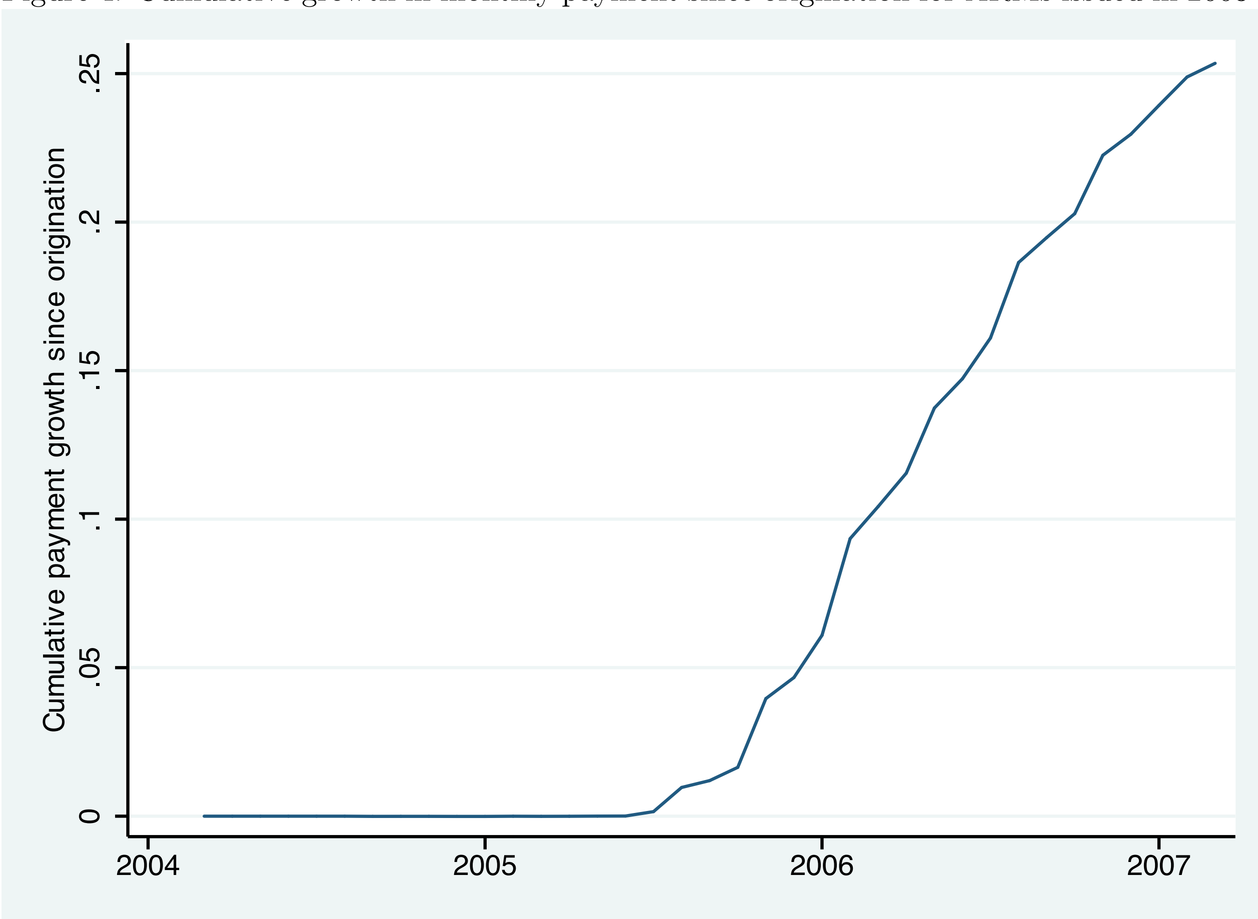


Panel B: Expectations as of 2004Q1



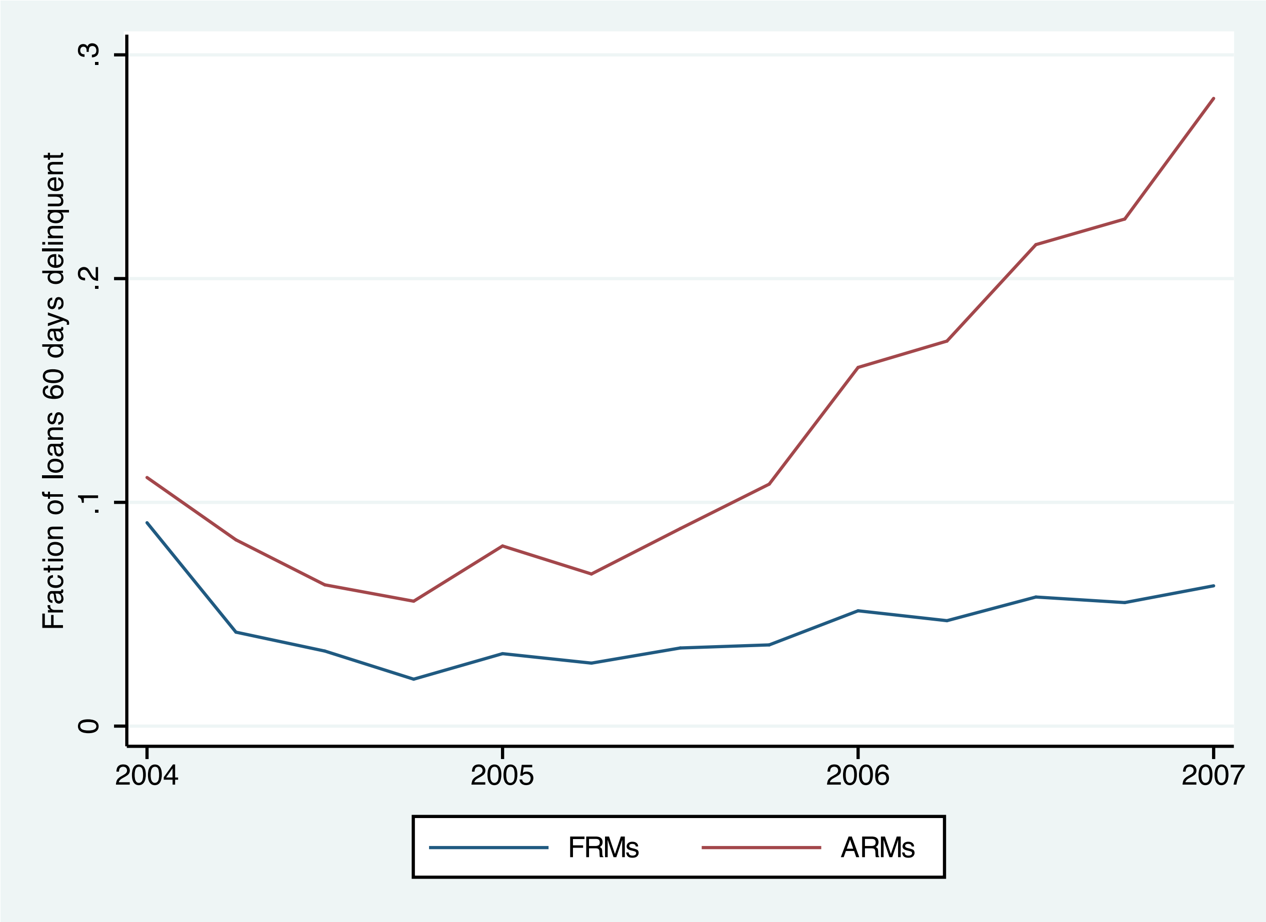
Note: Mean forecasters expectations about the 3m Tbill rates are from the Federal Reserve Bank of Cleveland website. Data on actual 3m Tbill rates are from theFerederal Reserve website.

Figure 4: Cumulative growth in monthly payment since origination for ARMs issued in 2003



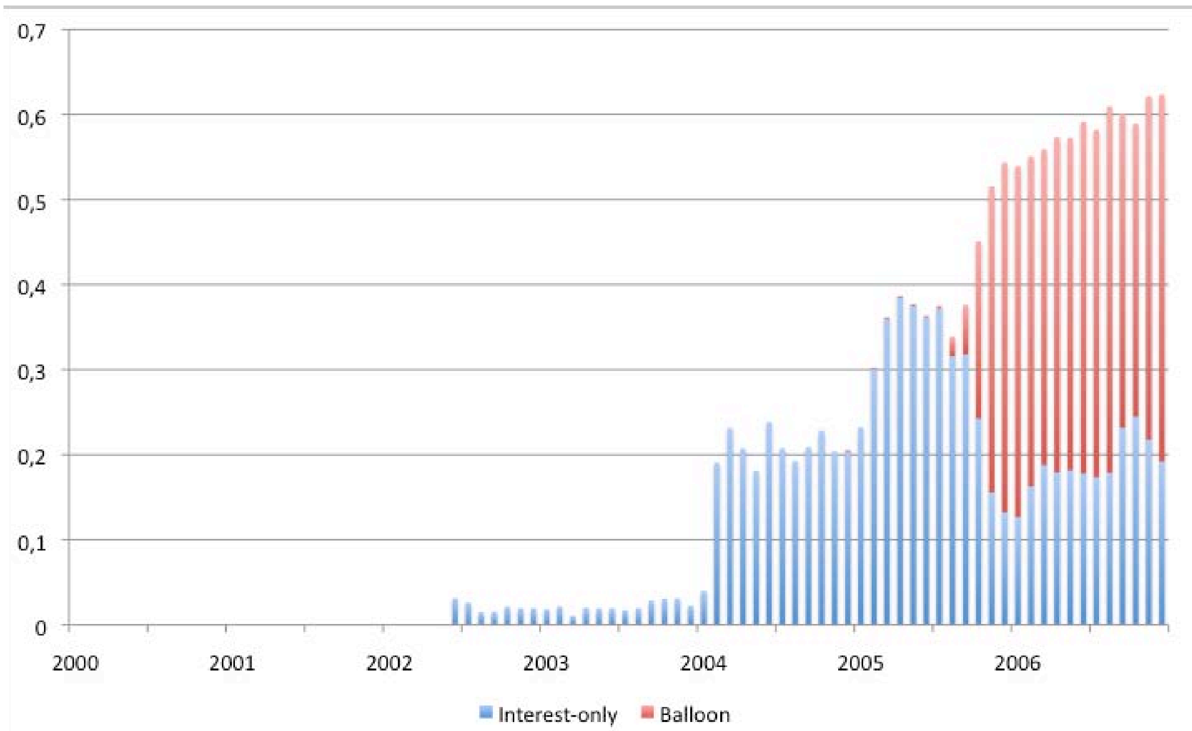
Source: Monthly payment data, Hybrid ARMs issued in 2003 only. For each ARM originated and serviced by New Century beyond its 12th month, we compute, each month, the cumulative growth in monthly payment since origination. We then compute the average of this cumulative growth for all ARMs still serviced for each month after January 2004.

Figure 5: Delinquency rates for ARMs and FRMs issued in 2003



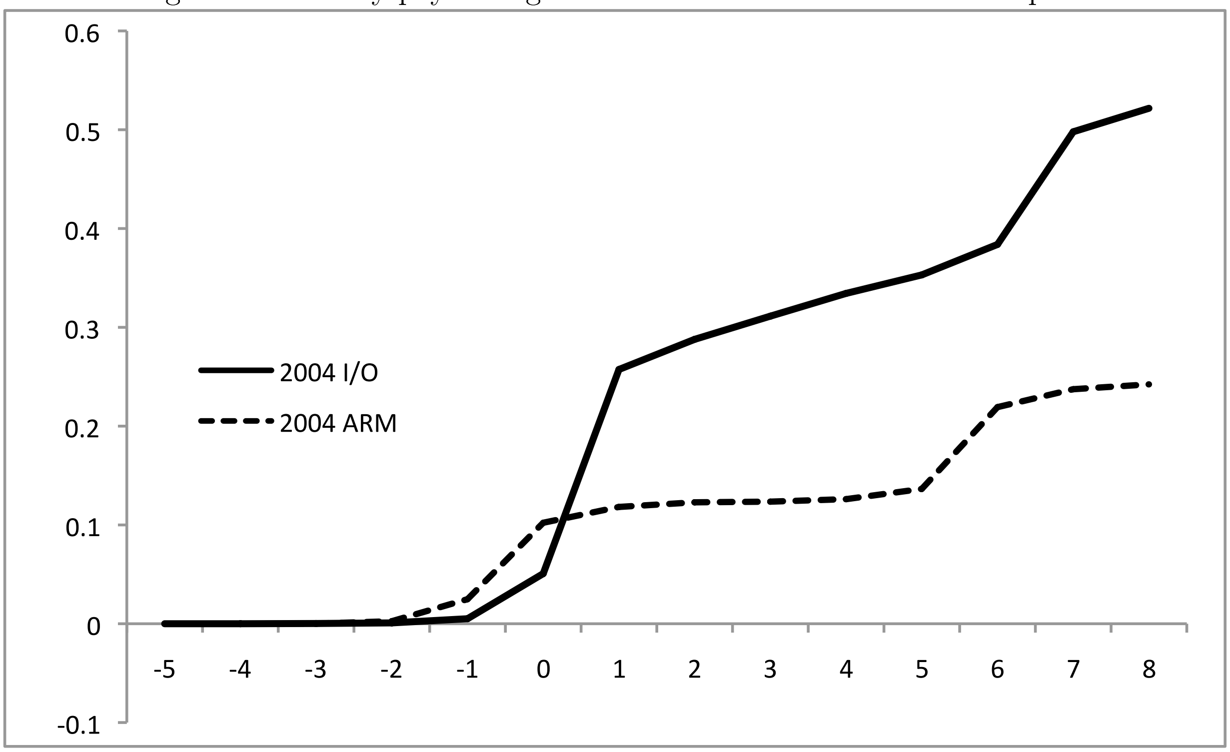
Source: Monthly payment data for all hybrid ARMs & FRMs. We restrict ourselves to loans issued in 2003 and still serviced by New Century after their 12th month of existence. Each quarter, for each of the two categories of loans, we compute the fraction of delinquent loans.

Figure 6: Fraction of deferred amortization loans originated



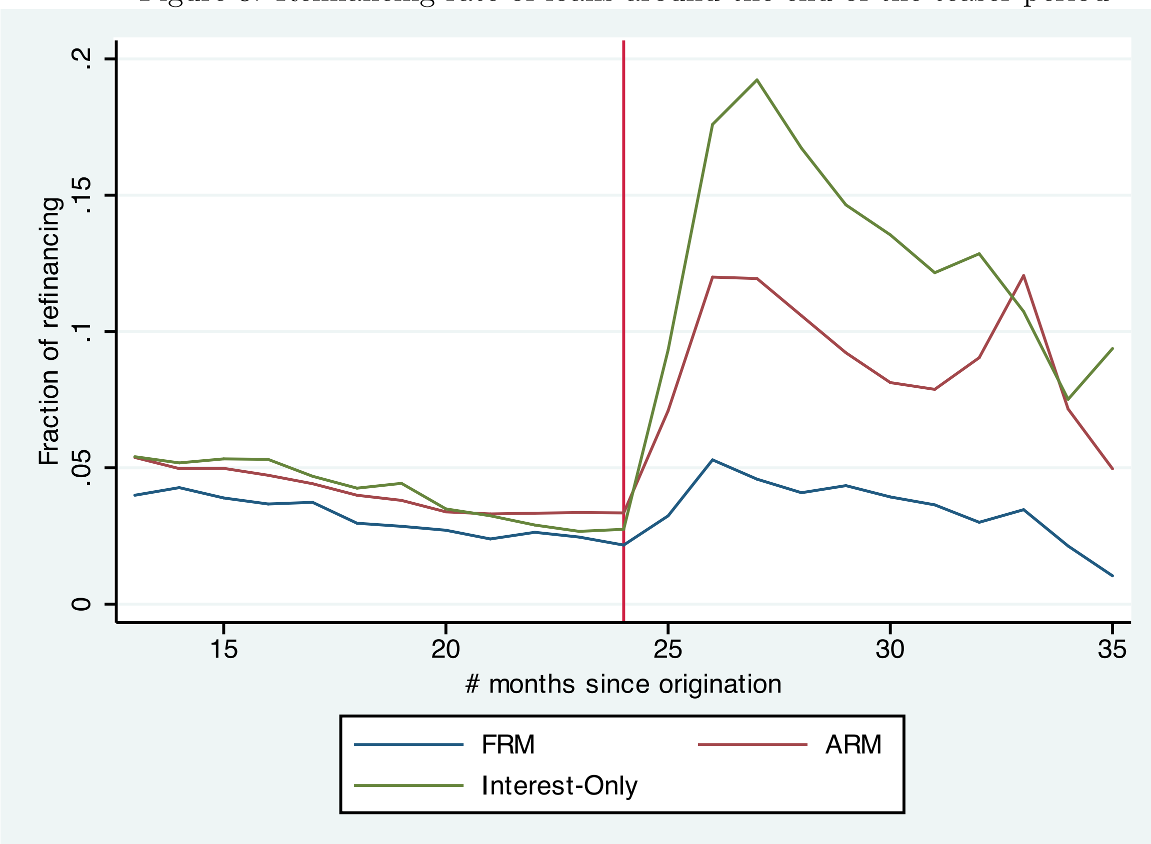
Note: Loan data, restricted to funded loans. In this figure, we plot the fraction of dollars originated as interest-only and balloon loans. Reading: in January 2006, interest-only loans accounted for about 12% of the overall amount originated. Balloon and interest-only loans together accounted for about 53% of total originations.

Figure 7: Monthly payment growth around the end of the teaser period



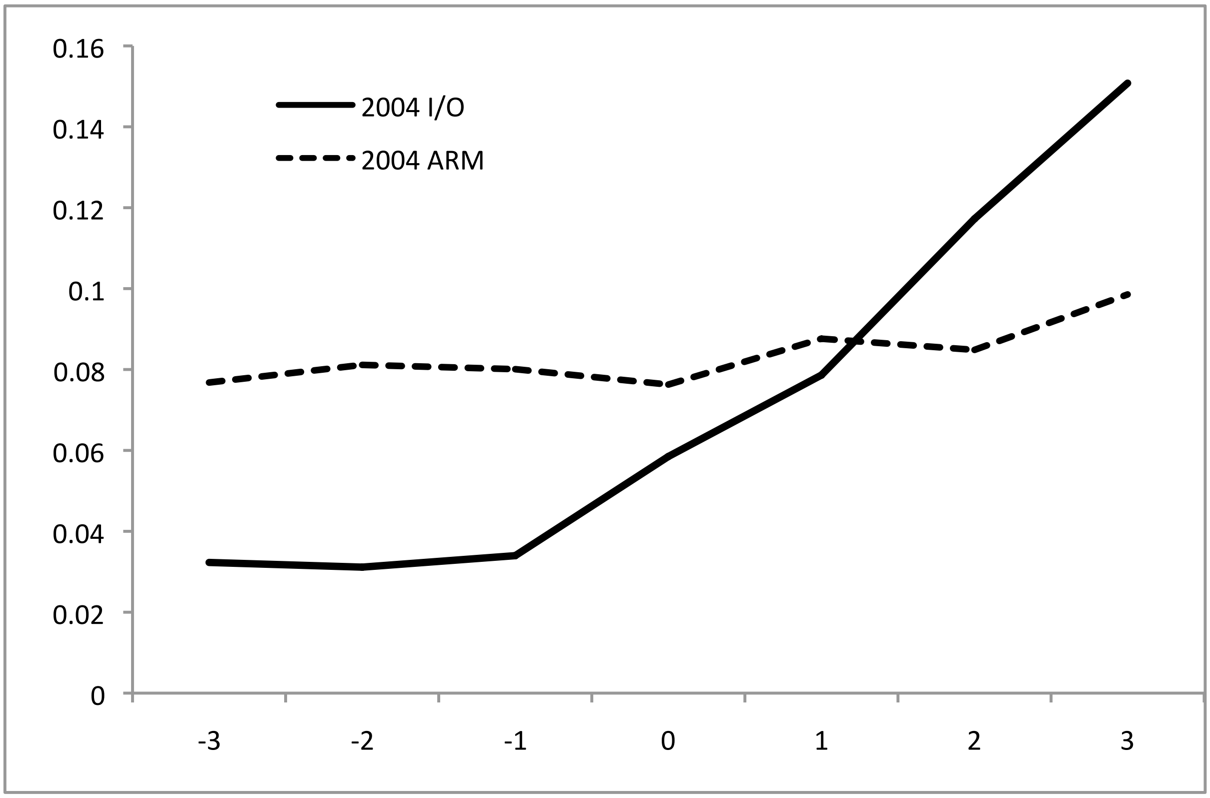
Source: Monthly payment data for loans issued in 2004 and still serviced by NewCentury after their 12th month of existence. For each loan-month that is present in the servicing data, we compute the growth rate in monthly payment due since 6 months before the end of the "teaser" period. Time is reported in months on the horizontal axis, where date zero corresponds to the end of teaser period. For all loans of a given type (ARM or Interest-only, issued in 2004), we compute the average of this growth rate. From this graph, we can see that, for ARMs originated in 2004, the monthly payment grew on average by almost 20% between 6 months before reset and 12 months after reset.

Figure 8: Refinancing rate of loans around the end of the teaser period



Source: Monthly payment data for loans issued in 2004 and still serviced by NewCentury after their 12th month of existence. Note: For each loan type, for each date around the end of the teaser period, we calculate the fraction of loans that exit the sample but are not delinquent. This is our proxy for "refinancing", which we do not observe directly. We are then showing the monthly rate of refinancing of loans, for each loan category.

Figure 9: Excess delinquency of loans originated in slow growing MSAs



Note: Monthly payment data. Seven months window around the the end of the teaser period. 0 means 24 months after origination; +3 means 27 months after origination. We first sort loans by home price growth quartiles in the 24 months that immediately follow the orignation. For each loan type (interest-only of ARM), we calculate, each month relative to the end of teaser period, the average delinquency rate of loans tracked by New Century, separately for MSAs in the top quartile and bottom quartile of price growth. In the Figure, we then report the difference between delinquency rates in bottom and top quartile of first 24 months price growth. the solid line reports the result for interest only loans; the dashed line for ARMs.

A. Data Appendix

In this paper, we use data from three sources: internal records of New Century (loan applications and loan repayments), city-level home prices from the OFHEO, and local information on home price to income and education from the 2000 Census.

A.1. New Century loan database

This Section describes the "loan database", which provides us with the characteristics of loans examined by NC. The "loan database" contains the universe of all 3.7m loan applications processed by New Century from 1997 to 2006. This database was maintained by NC for its operations and then sold by the firm's bankruptcy trustee (Berndt et al., 2010). It provides us with detailed information on borrowers, most notably whether the loan has full documentation, the loan to value ratio, income and FICO score. It also provides us with the zip code of the property being used as collateral in the transaction. Finally, the dataset entails information on the loan. In particular, we have information on the value of the principal, the status of the loan – whether it was funded, denied by NC or withdrawn by borrowers – whether the loan has fixed or variable rate (ARM or FRM), its maturity (30 years for 92% of the applications), the interest rate, the amortization schedule, the length of the teaser period (2 to 5 years) and the purpose of the loan (first purchase vs. refinancing).

Between 1997 and 2001, NC processed about 100,000 applications per year; the firm then grew steadily to process about 800,000 applications in 2006. Overall, 14.5% of these applications were denied by NC, and 42.8% were granted by NC, but declined by the prospects (Source: 10K filing, confirmed by internal data).

In all our regressions, we use the 2004 vintage of loans issued by NC. The main reason for this is that we need to track the performance of these loans at least two years of issue, while performance data stop in February 2007. 2004 is also the moment when we argue that NC started to risk-shift. Descriptive statistics for this subset of loans are provided in Table 1, Panel A. In terms of geographic dispersion, New Century makes loans in all 52 states, but lending activity is somewhat concentrated in high volume states. California (22.5% of all applications), Texas (9.5%) and Florida (8.5%) together represent more than 40% of all applications.

A.2. New Century servicing database

This Section describes the "servicing database", which monitors monthly loan performance for a subset of loans issued by NC. Beside its origination business, NC did also process loan repayment and organize recovery in case of default (the loan "servicing" business). As a servicer, NC would receive a fee on these operations and was thus maintaining a precise payment record for each borrower. The raw servicing database is a panel dataset that tracks each individual loan over time. It can be matched with the loan database through a unique loan identifying number. It provides information on loans repayment history and fees collected throughout the life of the loan.

NC did not service all the loans it originated. As of December 31, 2004, NC's balance of its loan servicing portfolio was $24.4 billion, consisting of $11.6 billion in mortgage loans held for investment, $3.9 billion in mortgage loans held for sale, $7.7 billion in interim servicing, and $1.2 billion in servicing rights owned. In particular, the 2004 10K filing reports that 90% of loans held for investment were serviced by New Century. As one can see from these numbers, 52% of loans serviced by NC are serviced on a temporary basis – i.e. before they are whole sold. As a consequence, these loans appear on the servicing sample for up to 6 months and then exit the sample. The servicing data does not say if a loan exits because it has been refinanced, defaulted upon, or sold to a third party, along with servicing rights.

To reduce this measurement problem, we focus our analysis on loans that are in the servicing data for at least 12 months after origination. The drawback of this selection process is that we cannot analyze the determinants of early payment defaults and early refinancing. The advantage is that we are more confident that the loans we analyze are permanently serviced by NC, and thus that exits either mean refinancing or default.

Thus, we focus on loans issued in 2004 and serviced by New Century beyond their 12th month of existence. The data we have stops in February 2007, and is therefore right censored. We only take observations beyond the 12th month. We end up with a panel dataset of 542,526 observations corresponding to 45,546 loans. The median lifetime, after origination, of these loans is 26 months (22 months if we restrict oursleves to loans ending before February 2007). This reflects the fact that these products were not supposed to be held to maturity but were destined to be refinanced before the end of the teaser period (Mayer, Pence and

Sherlund, 2009). Among the 45,546 loans in the our extract of the servicing data, 53% were standard hybrid ARMs, 30% were FRMs, and the remaining 17% were interest-only loans. This reflects the fact that, in 2004, interest-only loans were relatively new products. For all these loans, we observe, every month, the monthly payments, realized and due, the unpaid principal balance, loan delinquency etc.

An important question related to the servicing database is how representative it is from the loans originated by NC. 90% of the loans serviced on a permanent basis in 2004 were loans held for investment. As a consequence, the dataset is representative of loans held for investment. There is of course a strong presumption that these loans were not randomly selected among the set of loans originated by NC. We make this comparison in Table 1, Panel B, where we report mean loan characteristics from the loan database for loans serviced, and not serviced, by NC more than 12 months after origination. There are some statistically significant differences, but there are small economically, except for loan types (ARM, FRM, Interest-Only)

A.3. OFHEO and census data

We obtain house price indices (HPI) from the OFHEO website. HPIs are defined at the MSA level since 1973. They correspond to prices of observed transactions of single-family houses, whose characteristics (number of rooms, etc.) are controlled for using hedonic regression techniques. Geographic information in NC datasets does not have the MSA code but only the zipcode. Hence, home price information is matched with both New Century databases using a MSA-zipcode correspondence table retrieved from the Missouri Data Research Center.[20]

We also use data from the 2000 census, aggregated at the MSA level. We start with a household level 5% extract of the 2000 Census.[21] From this dataset, we retrieve the following variables: educational attainment (EDUC), poverty (POVERTY), total household income (HHINCOME) and self-reported property value for owner occupied homes (VALUEH). We then calculate, at the Census tract level, the fraction of households below the poverty line, the fraction of households with educational attainment corresponding to 8th grade or less, and the average house price to income. We then match this information with the loan database using a correspondence table between zip codes and census tract identifiers retrieved from the Missouri Data

[20]http://mcdc2.missouri.edu/websas/geocorr2k.htm
[21]Available from http://www.census.gov/main/www/pums.html

Center. A complication arises from the fact that some zip codes overlap several census tracts and some census tracts overlap several zip codes. Fortunately, the MDC provides us with the population in each tract x zip region, so that we end up taking, for each zip code, the average education level across tracts in this zip code, weighted by the population of each tract in this zip code.

B. Model Appendix

In this Appendix Section, we add some structure to the model in order to formally derive our three testable predictions. First, we assume that NC is originating mortgages in various region $s \in S$; local real estate price growth in region s is $\tilde{g}_s$. Without loss of generality, assume that $\mathbb{E}[\tilde{g}_s] = 0$. The return of a mortgage i in region s_i can be approximated by the following linear relationship:[22]

$$\tilde{R}_i = a_i + b_i.\tilde{g}_{s_i} + \tilde{u}_{s_i}, \quad \mathbb{E}[\tilde{u}_{s_i}] = 0 \tag{6}$$

Finally, real estate price growth in any region s is assumed to have a stable correlation with the firm's legacy asset returns, $\tilde{R}^A$, so that we can write:

$$\tilde{g}_s = \beta_s \times \left(\tilde{R}_A - \mathbb{E}[\tilde{R}^A]\right) + \tilde{\epsilon}_s, \quad \mathbb{E}[\tilde{\epsilon}_s] = 0 \tag{7}$$

House prices in high β_s regions are more likely to collapse when NC goes bankrupt. Combining (6) and (7), the NPV for NC's shareholders on the risky project becomes:

$$\mathbb{E}[\tilde{S}.\tilde{R}_i] = p\left(a_i + b_i\beta_{s_i} \times \left(\mathbb{E}\left[\tilde{R}_A|\tilde{R}_A > (1+r+\rho)D\right] - \mathbb{E}[\tilde{R}^A]\right)\right) \tag{8}$$

Consider now the trade-off between two different mortgages, $i = 1, 2$, from the point of view of NC's shareholders.Shareholders prefer mortgage $i = 1$ rather than mortgage $i = 2$ iff:

$$\mathbb{E}[\tilde{S}.\tilde{R}_{1,s_1}] > \mathbb{E}[\tilde{S}.\tilde{R}_{2,s_2}]$$

i.e.

[22] Empirically, b is positive. When prices go up, leverage goes down, so it is easier for borrowers to refinance the loan and lower monthly payments. Housing inflation thus increases returns on mortgages.

$$a_2 - a_1 < (b_1\beta_{s_1} - b_2\beta_{s_2}) \times \left(\mathbb{E}\left[\tilde{R}_A|\tilde{R}_A > (1+r+\rho)D\right] - \mathbb{E}[\tilde{R}^A]\right) \tag{9}$$

In other words, faced with the choice between two mortgages $(a_i, b_i, \beta_{s_i})_{i=1,2}$, shareholders trade-off between covariance with survival and expected returns.

To make predictions on the quantity of loans originated by NC, assume that NC randomly draws a large number of mortgage pairs and has to pick one in each pair (i.e. α, b and β_s are drawn from a p.d.f. $f(b)g(\alpha)h(\beta_s)$). Equivalently, one can assume that NC picks a predetermined number of loans within a large pool of independently drawn loans (rather than picking one loan among each pair). The independence of characteristics leads to tight predictions on the change in relative likelihood of different loans being originated under financial stress.

Prediction 1. *As monetary policy tightens, or as the value of the legacy asset drops, NC is more likely to originate high b loans, i.e. loans whose payoff is sensitive to local real estate prices.*

Proof. $\frac{\partial^2 discount}{\partial r \partial b} > 0$. Thus, NC is willing to take a steeper discount for loans that have a higher b. Thus, as the realized draw on b increases, NC will be more likely to accept the risky project, since it will be willing to accept a lower α and α and b are independent. □

Loans with a high correlation to real estate prices are indirectly more exposed to NC's legacy asset.[23]. As monetary policy becomes tighter – i.e. the realization of ρ is larger – $E(\tilde{R_A}|\tilde{R}_A > 1 + r + \rho)$ increases: NC's "legacy" asset has to perform better to save the firm from bankruptcy. This increases the bias of shareholders toward high covariance assets: for given a and β_s, the inequality that determines whether a loan is to be funded is fulfilled for a larger range of b. Thus loans with high correlation to real estate prices are relatively more likely to be desirable for NC shareholders following an increase in ρ. Next, consider a negative shock to $\tilde{R}_A$ by a constant δ. Since $\mathbb{E}\left[\tilde{R}_A - \delta|\tilde{R}_A - \delta > (1+r+\rho)D\right] - \mathbb{E}[\tilde{R}^A - \delta] = \mathbb{E}\left[\tilde{R}_A|\tilde{R}_A > (1+r+\rho)D + \delta\right] - \mathbb{E}[\tilde{R}^A] > \mathbb{E}\left[\tilde{R}_A|\tilde{R}_A > (1+r+\rho)D\right] - \mathbb{E}[\tilde{R}^A]$,it follows that the negative shock tilts NC's preferences in the direction of loans with a high b.

The second prediction is also a direct consequence of equation (9). For a given loan exposure to real estate price growth b, a distressed firm has a preference for regions where real estate prices are more correlated with its own "legacy" assets (i.e. high β_s regions). Again, this is a way for New Century to achieve higher exposure on their own portfolio of existing loans.

[23] This is the case only when $\beta_s \geq 0$ which empirically is the relevant situation

Prediction 2. *As monetary policy tightens, or as the value of the legacy asset drops, NC is more likely to originate loans in high β_s regions, i.e. regions where real estate prices covary more with its own legacy assets.*

Proof. $\frac{\partial^2 discount}{\partial r \partial \beta_s} > 0$. Thus, NC is willing to take a steeper discount for loans originated in regions that have a higher β_s. Thus, as the realized draw on β_s increases, NC will be more likely to accept the risky project, since it will be willing to accept a lower α and α and β_s are independent. □

The third prediction takes advantage of the complementarity between b and β_s in the expression of the discount.

Prediction 3. *As monetary policy tightens, or as the value of the legacy asset drops, NC is more likely to originate high b loans in high β_s regions: asset-sensitive regions receive a larger fraction of price-sensitive loans.*

Proof. $\frac{\partial^3 discount}{\partial r \partial \beta_s \partial b} > 0$. Thus, NC is willing to take a steeper discount for loans originated in regions that have a higher β_s, and even more so when the loans have a high sensitivity to house price growth, i.e. a high b. Thus, as the realized draw on β_s increases, NC will be more likely to accept the risky project if it has a large b than if it has a small b, since it will be willing to accept a lower α and α, β_s and b are independent. □