

# How Do Regulators Influence Mortgage Risk?

## Evidence from an Emerging Market\*

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### Abstract

To understand the effects of regulation on mortgage risk, it is instructive to track the history of regulatory changes in a country rather than to rely entirely on cross-country evidence that can be contaminated by unobserved heterogeneity. However, in developed countries with fairly stable systems of financial regulation, it is difficult to track these effects. We employ loan-level data on over a million loans disbursed in India over the 1995 to 2010 period to understand how fast-changing regulation impacted mortgage lending and risk. We find evidence that regulation has important effects on mortgage rates and delinquencies in both the time-series and the cross-section.

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# 1 Introduction

How does mortgage regulation influence the structure and performance of housing finance? This paper answers the question by analyzing administrative data on over 1.2 million loans originated by an Indian mortgage provider, relating loan pricing and delinquency rates to the changing details of Indian mortgage regulation.

A more common approach to this question is to compare mortgage systems across countries. Casual observation reveals striking cross-country differences. A recent survey by the International Monetary Fund (IMF 2011) shows that among developed countries, homeownership rates range from 43% in Germany to about 80% in southern European countries. The level of mortgage debt in relation to GDP varies from 22% in Italy to above 100% in Denmark and the Netherlands. The terms of mortgage instruments are overwhelmingly adjustable-rate in southern Europe, and fixed-rate in the United States. Mortgages are funded using a wide variety of mechanisms, including deposit-financed lending, mortgage-backed securities, and covered bonds.

Government involvement in mortgage markets also varies across countries, and it is likely that this explains at least some of the cross-country variation in housing finance. However, it is hard to disentangle regulatory effects from other factors that may affect household mortgage choice across countries, including historical experiences with interest rate and inflation volatility, which can have long-lasting effects because consumers can be slow to adopt new financial instruments (Campbell 2012). An appealing alternative approach is to trace the effects of mortgage regulation over time within a single country rather than rely entirely on cross-country evidence that can be contaminated by unobserved differences across countries. The difficulty in doing this is that developed countries tend to have fairly stable systems of financial regulation, so one rarely has the opportunity to track the effects of sharp regulatory changes. Slow changes, such as those that occurred in the US during the early and mid-2000s, may well be important but it is hard to show this convincingly. For this reason academic writers and public policy commentators have reached no consensus on the degree to which regulation, rather than other factors, caused the US mortgage credit

boom.<sup>1</sup>

Mortgages are rapidly becoming important financial instruments in emerging markets. Here, financial regulation is at least as intrusive and much less stable. In addition, long-lasting historical influences are likely to be less important in emerging markets because their rapid growth and financial evolution reduce consumer inertia. For this reason, emerging markets are ideal laboratories in which to examine the effects of mortgage regulation. However emerging markets pose a different challenge, that of finding adequate data. Many questions about mortgage finance can only be answered using microeconomic data, either at the household level or the loan level. There is now a vast literature looking at such data in the US, but it is harder to find in less wealthy countries with rapidly changing financial systems.<sup>2</sup>

This paper uses high-quality microeconomic data to study the mortgage market in India, a large and complex emerging economy. India underwent an economic liberalization in the early 1990s and subsequently experienced rapid economic growth that accelerated further in the 2000s. During this time the financial sector has become much larger and more sophisticated, but remains highly regulated, with a significantly nationalized banking sector. The provision of housing finance is particularly fast-changing (Tiwari and Debata 2008, Verma 2012). Regulatory norms have changed frequently, albeit with a continuing emphasis on funding housing for low-income households. There is increased competition between mortgage lenders, and this may have contributed to rapidly increasing house prices since 2002. Indian mortgages include both fixed and variable rate loans, but there has been a significant shift over time towards the latter.

We are fortunate to have access to loan-level administrative data from an Indian mortgage provider. We analyze over 1.2 million mortgages disbursed by the mortgage provider between

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<sup>1</sup>A range of views can be found in Acharya, Richardson, van Nieuwerburgh, and White (2011), Baily (2011), Ellis (2008), International Monetary Fund (2011), and US Treasury and Department of Housing and Urban Development (2011), among other sources.

<sup>2</sup>Some recent mortgage studies using US microeconomic data include Adelino, Gerardi, and Willen (2009), Agarwal et al (2011), Amromin et al (2011), Bhutta, Dokko, and Shan (2010), Demyanyk and van Hemert (2011), Foote et al (2010), Johnson and Li (2011), Keys et al (2010), Melzer (2011), Mian and Sufi (2009), and Piskorski, Seru, and Vig (2011).

1995 and 2010, and attempt to understand both the macroeconomic and microeconomic determinants of mortgage rate setting and delinquencies. These data reveal three interesting findings which relate regulation to mortgage risk. First, simple plots reveal a significant spike in delinquencies in the early 2000s. When we estimate a model which relates delinquencies to demographic information, loan characteristics, and macroeconomic shocks, we find that even after controlling for these determinants, the spike in delinquencies shows up in the cohort effects for loans issued in those years. We connect these estimated cohort effects to a number of regulatory changes which encouraged mortgage lending at that time, and we regard this as compelling evidence for regulatory effects on mortgage defaults.

Second, in addition to this time-series evidence on aggregate mortgage default rates, we provide evidence on the impacts of regulation from the cross-section of defaults conditioned on various loan attributes. In particular, throughout the period of study, small and micro loans are particularly favoured by the Indian regulatory environment. We uncover evidence that the implicit subsidies to such loans show up in a higher propensity for them to default than can be accounted for by their mortgage rates at issuance and all other determinants in the model. This tendency is highly statistically significant, is greater for micro loans than for small loans just under the subsidy-qualifying threshold, and is observed in all cohorts of loan issuance over the sample period. We also find that the magnitude of the excess delinquency propensity of small and micro loans appears to vary over time in a way that can be connected to the tightness of the constraint favoring these loans.

Third, we find a significant and somewhat abrupt decline in three-month payment delinquencies beginning in early 2004. We connect this finding to the fact that the regulatory definition of “non-performing assets,” a definition which is associated with provisioning requirements against such delinquent loans, changes in March 2004, from previously referring to loans that are six-months delinquent to those that are three-months delinquent. Using a subsample of 10,000 loans for which we have a complete time-series of payment histories, we uncover evidence that is consistent with more effort on the part of the mortgage provider to monitor delinquencies in response to this regulatory change. In particular, we find that one-month delinquent loans are less likely to subsequently become three-month delinquent

following this change in definition; moreover repayments are accelerated on both one-month and three-month delinquent loans after this change.

Taken together, these three findings provide strong evidence that a range of regulatory norms impact the risk of delinquencies experienced by our Indian mortgage provider on loans issued. Our evidence complements recent findings using U.S. data on the impacts of regulatory norms on mortgage screening (Keys et al. 2011), and is also related to work on how mortgage credit expansion in the U.S., particularly in sub-prime zipcodes, contributed to the recent crisis (Mian and Sufi 2009). Our model shows that controlling for a range of determinants of mortgage risk, the time when a loan is issued has significant explanatory power, a finding related to the analysis of Demyanyk and van Hemert (2011) who perform a similar analysis to explain U.S. sub-prime mortgage risk. Finally, our findings appear to present a challenge to Kashyap, Rajan, and Stein (2008), who suggest that capital requirements against risk-weighted assets should be countercyclically adjusted – we find that a reduction in the risk-weight on housing finance following a period of low GDP growth is associated with high levels of mortgage delinquencies for loans issued in those cohorts.

The organization of the paper is as follows. Section 2 sets the stage by describing the Indian macroeconomic environment over our period of study, the mortgage data that we employ, and summarizes the Indian system of mortgage regulation. Further details on that system are provided in an online regulatory appendix (Campbell, Ramadorai, and Balasubramaniam 2012). Section 3 introduces our model of mortgage delinquencies, which we use to show that changing demographic characteristics of borrowers, loan characteristics, or estimated macro shocks cannot fully explain the high delinquency rate in the early 2000s. Instead, changing regulation to encourage mortgage lending appears to be responsible. Section 4 presents evidence that regulation has also affected the relative pricing of small and large mortgages, and discusses the change in the regulatory definition of non-performing assets in 2004 and its consequences on observed delinquency and repayment patterns. Section 5 concludes. Additional empirical evidence on the Indian mortgage market is reported in an online empirical appendix (Campbell, Ramadorai, and Ranish 2012).

## 2 The Macroeconomic and Regulatory Environment

### 2.1 Macroeconomic and Mortgage Finance Trends

To set the stage, Table 1 illustrates the history of several important macroeconomic variables over the past quarter-century in India, including annual real GDP growth, CPI inflation, and government bond yields. Regulatory and macroeconomic reform in the early 1990s was followed by growth in the 4-8% range until the early 2000s, when growth accelerated above 8%, briefly slowed again only by the global financial crisis in 2008. Meanwhile inflation was high and volatile during the 1990s, with volatility particularly elevated around the reform period and in 1998–99. A period of more stable inflation followed in the 2000s, but inflation accelerated at the very end of our sample period.

Indian government bond yields over the same period are also quite volatile. The 1-year yield declines from double-digit levels in the mid-1990s, with considerable volatility in the late 1990s related to the volatile inflation experienced at the same time. After a low of about 5% in the early 2000s, the 1-year yield spikes up in 2008, again related to concerns about inflation. The 10-year yield is smoother but also undergoes a large decline from the mid-1990s until the early 2000s.

Figure 1 plots house price indexes, both for India as a whole and for five broad regions. We compute the indexes using the mortgage provider’s own property cost data, but data from the National Housing Bank (NHB) show similar patterns. Indian house prices were relatively stable until the early 2000s and then began to increase rapidly, particularly in the south of the country. The southern index peaks in 2008 while some other regions peak in 2009. Thus India took part in the worldwide housing boom despite many differences in other aspects of its macroeconomic performance.

Over this same period, the Indian mortgage market was experiencing rapid change. Figure 2 illustrates one aspect of this change, namely a shift from a predominantly fixed-rate mortgage system to one that is dominated by variable-rate lending. The figure plots the share of variable-rate loans in total issuance by our mortgage provider. Starting at about 40% of dollar value in the mid-1990s, the variable-rate share increases above 90% by the

early 2000s, then briefly dips to 60% in 2004 before again rising and reaching 100% by the end of our sample period. The cause of the brief shift back towards fixed-rate mortgages in 2004 is an interesting question that we discuss later in the paper.

Figure 3 plots the delinquency rate (the fraction of mortgages that are 90 days past due), seasonally adjusted using a regression on monthly dummies, for both fixed-rate mortgages (solid line) and variable-rate mortgages (dashed line). The main feature of this figure is a large spike in delinquencies in 2002–03, particularly for fixed-rate mortgages. This spike is one of the features of the data that we attempt to explain using our model, which we introduce in the next section. Delinquencies decline to quite low levels by 2005, and remain low to the end of our sample period despite the weak housing market in 2009–10.

Table 2 shows how our mortgage lender responded to the market conditions described above. Panel A reports cross-sectional means of mortgage terms and delinquency rates. Initial interest rates on variable-rate and fixed-rate mortgages track one another very closely until 2002, and are both close to the Indian prime rate shown in Table 1, despite some variation in the spread between long-term and short-term government yields. In the period 2003–06, the variable mortgage rate is well above the fixed rate and has an unusually high spread over the 1-year bond yield, a feature shared with the Indian prime rate. This period has a generally high market share for variable mortgages, but does include the episode in 2004 when our mortgage lender shifted back towards fixed mortgage issuance. Variable mortgage rates decline after 2008, a period where fixed mortgages have essentially disappeared from our dataset.

The right-hand column reports the cohort 90-day delinquency rate, the annual probability that an outstanding and not-yet-delinquent loan experiences a 90-day delinquency, calculated separately for each disbursal-year cohort and calendar year, and then averaged over calendar years for each cohort. The early 2000s appear unusual in the sense that the cohort default rate for mortgages disbursed in these years is high relative to the other cohorts in the sample period, despite loan characteristics such as loan-to-cost and loan-to-income ratios not changing much on average. The 2004 cohort, especially for fixed rate loans, however, appears to have a significantly reduced default rate, which we connect to the spike in fixed

rate issuance later in the paper.

Panel B of Table 2 shows the cross-sectional standard deviation of loan characteristics and initial interest rates. In the early 2000s there is a large spike in the cross-sectional dispersion of variable mortgage rates. This spike coincides with the period of increased delinquencies documented earlier, and may reflect increased efforts by our mortgage lender to distinguish among borrowers by estimating their default risk and setting mortgage rates accordingly. For fixed mortgage rates, while the same pattern is not evident in the cross-sectional dispersion of initial interest rates, there does seem to be an increase in the early 2000s in the cross-sectional dispersion of loan-to-cost ratios, which reduces again in 2004.

In the remainder of this paper, we relate several of the summary statistics described above to changes in the Indian regulatory environment for housing finance. Our empirical work requires a basic understanding of the regulatory structure in India, to which we turn in the next section.

## 2.2 The Regulatory Environment

Mortgages in India are originated by two types of financial institutions, banks and housing finance companies (HFCs). Banks are regulated by the Reserve Bank of India (RBI), while housing finance companies are regulated by the National Housing Bank (NHB), but most regulations apply in fairly similar form to the two types of institution, which is helpful, as we are unable to publicly identify whether our mortgage provider is a bank or an HFC.

Figure 4 summarizes the details of mortgage regulation in India in a relatively parsimonious fashion. The top half of the figure shows regulations that applied to banks, and the bottom half to HFCs. The regulations that remained constant throughout the period are listed in black, whereas the ones that changed over the period are in colored font. In light of the significant changes that took place from 2001 to 2002, we separate the timeline into the “first period,” i.e. prior to March 2001, and the “second period” which extends from April 2001 until the end of the sample period. In the middle of the figure, we summarize subsidy schemes for micro-lending with the length of the bars accompanying these schemes



identifying their start and end dates relative to the timeline.

Regulations can be divided into two types: those that restrict the funding of mortgage lending, and those that incentivize lending to favored borrowers. Until 2001, mortgage funding was regulated in a fairly traditional manner, using leverage restrictions on banks and HFCs, and interest-rate ceilings on deposit-taking HFCs. From 2002 onwards, these measures were augmented by capital requirements against risk-weighted assets following the internationally standard Basel II framework. The RBI and NHB distinguished small and large loans, and loan-to-value ratios above and below 75%, and set different risk weights for these different categories with frequent changes, thereby shifting the risk capital available to banks and HFCs, and the incentives for aggressive mortgage origination.

Another noteworthy change in the regulatory environment is highlighted on the timeline, and occurred on March 31, 2004 for banks, and one year later, i.e., March 31, 2005 for HFCs. At this time the RBI redefined an asset as a “non-performing asset” (or NPA) if payments (on interest or principal) remained overdue for a period of ninety days or more, from the previous 180 day period allowed before assets were so classified. One important implication of the classification of an asset as an NPA is that it incurs provisioning requirements, meaning that the capital available to a mortgage lender holding such an asset reduces as the lender is required to hold precautionary capital to cover expected losses.

Lending to small borrowers is an important political goal in India. Banks are subject to a quantity target for Priority-Sector Lending (PSL), which includes loans to agriculture, small businesses, export credit, affirmative action lending, educational loans, and – of particular interest to us – mortgages for low-cost housing. The PSL target is 40% of net bank credit for domestic banks (32% for foreign banks), and there is a severe financial penalty for failure to meet the target, namely, compulsory lending to rural agriculture at a haircut to the repo rate. This regulation does not directly apply to HFCs, but bank lending to an HFC qualifies for the PSL target to the extent that the HFC makes mortgage loans that qualify, i.e., are below the specified nominal PSL threshold. The overall effect of the PSL system is to provide a strong incentive, directly for banks, and indirectly for HFCs, to originate small mortgages that finance low-cost housing purchases.

In addition to the PSL system, other schemes have been introduced at various points in time over the sample period to subsidize new or refinanced micro-lending – i.e., at levels well below the PSL-qualifying threshold. The mid-section of Figure 4 shows the various schemes that were in place to incentivize mortgage lending in very small loan sizes. These schemes apply to both banks and HFCs. Most recently, interest rate subventions have been put in place for the first year of repayments on small loans, payments that are passed through to the borrower in the form of a reduced interest rate, for housing loans up to a maximum size. Special subsidy and refinancing schemes in place for very small rural loans (the Golden Jubilee Rural Housing Finance scheme or GJRHS, and the Indira Awas Yojana) and borrowers qualifying for affirmative action (the Differential Rate of Interest scheme) are also shown in the figure, over the period for which they applied. Taken together, these schemes increase the subsidy for tiny loans over and above the standard subsidy to PSL-qualifying loans.

As is evident from the brief description above, it is not a trivial task to document the changes in the Byzantine system of Indian mortgage regulation as these have been frequent, and not summarized in any one place. The online regulatory appendix to this paper, Campbell, Ramadorai, and Balasubramaniam (2012), provides further details about the regulatory system.

### **3 A Model of Mortgage Delinquencies**

In this section we attempt to shed light on the factors which contributed to changes in the mortgage delinquency rate over time and across cohorts, paying special attention to the changing regulations described in the previous section. In order to do so, we propose and estimate a model of mortgage delinquencies, recognizing that their determinants include demographic characteristics of borrowers, measurable characteristics of loans, cohort-specific variation, and (imperfectly observable) variation in macroeconomic conditions.

We model the probability of observing a delinquency as a function of all of these deter-

minants:

$$\Pr[\delta_{i,c,b,t}] = (\alpha + \alpha_c + \alpha_b + \sum_k \beta_k L_{ik} + \sum_j \gamma_j D_{ij} + \rho r_{i,c,b}) Z_{t-1} + e_{i,c,b,t}^\delta, \quad (1)$$

where  $\delta_{i,c,b,t}$  is an indicator for an observed 90-day delinquency in loan  $i$  in cohort  $c$  originated in branch  $b$ , at time  $t$ . That is,  $c$  denotes the loan origination date and  $t$  denotes the delinquency date. The model includes fixed effects for branches,  $\alpha_b$ , and cohorts,  $\alpha_c$  (in each case, we drop one dummy as we have an intercept in the model). It also includes loan characteristics  $L_{ik}$  indexed by  $k$ , and demographic characteristics  $D_{ij}$  indexed by  $j$ , for each borrower  $i$ . The initial interest rate on the mortgage,  $r_{i,c,b}$  is also included as an explanatory variable in the model.<sup>3</sup>

Finally, the model allows for an unobserved macroeconomic shock  $Z_{t-1}$  to impact these determinants multiplicatively. Thus the estimated coefficients on the branch and cohort fixed effects, loan and demographic characteristics show the extent to which these factors alter the propensity for a loan to default as macro conditions vary. To fix ideas, consider a high estimated value of a particular cohort effect – this would indicate a high propensity of loans in that cohort to default when times are bad, i.e., when  $Z_{t-1}$  is high. The choice of  $Z_{t-1}$  rather than  $Z_t$  as the macroeconomic shock influencing delinquency at time  $t$  captures the fact that 90-day delinquencies are not realized contemporaneously with deteriorations in macroeconomic circumstances. Rather, we expect to see delinquencies materialize some period of time after negative macroeconomic shocks, as delinquencies result from borrower-level cash-flow problems, which likely occur with a lag.

We estimate the model separately for fixed-rate and variable-rate loans, employing a two-stage estimation procedure, in which the first stage comprises  $T$  cross-sectional regressions estimated across all loans outstanding in each year  $t \in T$ . In the second stage, we employ the classical minimum distance estimator (see, for example, Wooldridge (2002)) to extract estimates of  $Z_t$  and the static parameters of the model. As a check on our procedure, we

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<sup>3</sup>The model is estimated at the annual frequency  $t$ ; to eliminate monthly variation, we de-mean all left- and right-hand side variables at the monthly frequency and add back the annual mean. This change is innocuous, having little impact on our results.

confirm that two-stage estimation produces estimates that are very close to those obtained via single-step estimation using non-linear least squares. To obtain standard errors for the second stage estimates we use a cross-sectional correlation consistent bootstrap procedure, in which we draw a set of time periods equal to the total number of years (15) in our data  $t_b^1, \dots, t_b^{15} \in T$  with replacement, and assemble a simulated dataset for each bootstrap draw  $b$ . We then re-run the second stage regressions for  $b = 500$  draws.

The demographic variables that we employ include the borrower’s gender, marital status, number of dependents, and dummies for age (up to age 35, 36-45, and 46 and above), for education (high-school measured by higher-secondary certificate or HSC, college, postgraduate, and missing), for a finance-related educational qualification, and for a repeat borrower. The loan characteristics include the log loan-to-cost ratio, log loan-to-income ratio, a piecewise linear function of log loan size in relation to the PSL threshold (discussed in more detail later in the paper), dummies for origination branch, dummies for whether the loan was paid by salary deduction or via a special scheme with the employer, as well as dummies for specific loan purposes (home extension or improvement), and mortgage contract terms (loan maturities 6-10 years, 11-15 years, or 16 years and above). To control for house-price movements, we also include in the set of loan characteristics regional house-price appreciation up to time  $t$  from the time of the disbursal of the loan.

### 3.1 Regulation and Delinquencies: Time-Series Evidence

Table 3 shows the estimated coefficients on the demographic and loan characteristics from equation (1), which predominantly appear to have signs consistent with intuition about their likely impacts on delinquencies. For the sake of brevity, Table 3 does not present the estimated macroeconomic shocks and cohort effects with associated standard errors, but we present these in the online empirical appendix (Campbell, Ramadorai, and Ranish 2012). We do plot these series, however, in Figures 5 and 6.

Figure 5 plots the estimated macroeconomic shocks  $Z_t$ . Our estimates are weighted by the relative fractions of fixed and variable rate loan issuance from the separate specifications

that we estimate for these two types of loans, a strategy that we continue to adopt in the remaining figures in the paper in order to conserve space. The figure also shows two different measures of macroeconomic conditions: real GDP growth, and the average real rate of growth in corporate sales, firm fixed assets, and firm net worth estimated from the population of Indian firms available in the Prowess database.<sup>4</sup> The figure, in which all series are standardized for ease of comparison, shows that estimated  $Z_t$  seems closely, but not perfectly related to these other measures. All three measures indicate that 2002 and 2003 were periods of particularly poor macroeconomic conditions, with a complete recovery in the Indian macro environment only by 2005.

Figure 6 plots the estimated cohort effects ( $\alpha + \alpha_c$ ) from the model, again weighted by loan issuance across fixed and variable rate loans. These cohort effects capture the impact of being issued in a particular year on the probability of experiencing a delinquency, controlling for other macro- and micro- determinants. While the estimation of the cohort effects already controls for variation in interest rates at the loan level, we can further control for aggregate interest rate variation (which in general may have a different impact) by regressing the cohort effects onto the cohort average interest rate. We call the fitted value of this regression the cohort average interest rate effect, and the residual the cohort quantity effect. The cohort quantity effect captures the impact on delinquencies purely arising from the quantity or types of loans issued in a particular cohort.<sup>5</sup>

Figure 6 shows that the cohort average interest rate component is far less important than the cohort quantity effect, although towards the end of the sample period, the interest rate component does increase in importance, and moves in the same direction as the cohort quantity effect. A striking feature of this plot is that the spike in the delinquency rate in 2002, 2003, and 2004 is attributed almost entirely to the cohort quantity effect.

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<sup>4</sup>This database comprises the population of listed and large unlisted Indian firms, and is considered to be the main source of information on Indian corporates (see, for example, von Lilienfeld-Toal, Mookherjee, and Visaria (2012)).

<sup>5</sup>We also estimate a version of equation (1) in which we replace the interest rate at issuance with the spread over one-year (in the case of variable rate loans) or ten-year (fixed-rate) loans. The resulting figure is presented in the online empirical appendix, and is similar to Figure 6, although somewhat noisier given the imperfect benchmark adjustment.

Figure 7 plots the demeaned cohort quantity effect from Figure 6, with two lines superimposed that summarize relevant changes in the regulatory environment for both banks and HFCs. The solid line shows the interest-rate ceiling applied to deposits issued by HFCs minus the yield on one-year Indian Government bonds. This spread is multiplied by five for scaling purposes and its scale is shown on the right vertical axis. From 1997 until 2001 there was no interest-rate ceiling, but a ceiling was reintroduced in 2002 and slightly tightened in 2003 and again in 2004. The cohort quantity effect during the period with no interest-rate ceiling steadily increases (as, in fact, does the cohort average interest rate effect), i.e., the absence of an interest-rate ceiling is associated with steadily increasing delinquency rates. While this is consistent with the view that a relatively unrestricted supply of credit to HFCs in this period stimulated lending, with delayed consequences for default, this must be viewed with the caveat that we are unable to publicly identify whether our mortgage provider is a bank or an HFC. Mian and Sufi (2009) present a similar view of developments in the US during the 2000s.<sup>6</sup>

The other, dashed line in Figure 7 summarizes changing risk weights for housing loans, following their introduction in April 2001, constructed by averaging the risk weights that apply to banks and to HFCs, and scaled as shown on the right vertical axis. The figure plots  $(100\% - \text{Risk Weight})$ , as a measure of the looseness of the restriction on lending. The loosening of the risk weight restriction in 2002 and 2003 coincides precisely with the higher delinquency rates in those years, and a subsequent tightening of the risk weight restriction in 2005 and 2006 coincides with unusually low delinquency rates. In 2004, despite continued loose risk weight restrictions, the cohort quantity effect is slightly lower than its level in 2003, and we connect this to the shift away from variable-rate to fixed-rate loans by the mortgage provider – the online empirical appendix plots the cohort quantity effects separately for fixed and variable loans, and shows that the 2004 cohort effect is relatively lower for fixed-rate loans than for variable-rate loans.

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<sup>6</sup>In the online empirical appendix, we also plot the cohort average interest rate component alongside the regulatory series, and show that the deposit interest rate ceiling does appear to vary alongside this component of the cohort effects.

In sum, while one must always be cautious about the interpretation of any pure time-series correlation, Figure 7 is strongly suggestive that changes in regulation drove the aggregate delinquency patterns in our data.

## 4 Regulation and Delinquencies: Cross-Sectional Evidence

### 4.1 The Effect of Priority Sector Lending Norms

Risk weights and interest rate ceilings are not the only regulatory instruments through which the Reserve Bank of India affects mortgage lending and risk. Priority-sector lending (PSL) norms also exist and have cross-sectional effects, diverting lending towards favored small loans. They do this both through the RBI's quantity targets for banks, and currently, through interest-rate subventions for loans up to a certain size. If PSL norms are important, they might induce mortgage lenders to make riskier loans to small borrowers.

Table 4 presents statistics on the importance of priority-sector lending by our mortgage provider, showing the fraction of loan value issued below the prevailing nominal PSL-qualifying threshold in each year from 1995 to 2010. For variable rate loans, this fraction declines from roughly 70% in the early years of our sample to 33% in 2010. Micro-loans (which we classify very simply as those smaller than one-half of the PSL-qualifying threshold) account for between a third and a little more than a half of the total set of PSL-qualifying variable rate loan issuance. For fixed rate loans, the fraction of PSL-qualifying loans in total issuance by value fluctuates between 65% and 85%, with a sharp reduction in 2004 to 48% of total loan issuance. This reduction in 2004, when combined with the lower fixed rate cohort effect in that year which we refer to in the previous section, suggest that the mortgage provider reduced its reliance on these (potentially more risky) loans in 2004.

Of course, mortgage lenders might make risky small loans in the absence of any regulatory incentives, if they are able to charge higher mortgage rates to compensate for the higher risk (Duca and Rosenthal 1994). As a first simple way to evaluate whether loans below the PSL

qualifying threshold are riskier even after controlling for mortgage rates, Table 3 allows for separate slopes for loan sizes above and below the PSL threshold at loan disbursement when estimating equation (1). If subsidies are responsible for the relationship between loan size and the propensity to be delinquent, then the slope below the PSL threshold should be estimated to be negative and statistically significant, because as we know from Figure 4, there are additional subsidies for micro-lending at loan sizes well below the PSL threshold. However, there should be no consistent relationship between loan size and the propensity to be delinquent for loan sizes above the PSL-qualifying threshold.

Table 3 shows that this is indeed the case – for each percentage point reduction in the size of the loan amount as a fraction of the PSL-qualifying threshold below the threshold, the propensity for a loan to be delinquent rises substantially for both variable rate loans and fixed rate loans. These coefficients are highly statistically significant. However, above the PSL-qualifying threshold, while there is a small and marginally statistically significant negative slope estimated for variable rate loans (roughly one-fifth the size of the slope below the threshold), the slope is small, *positive* and marginally statistically significant for fixed rate loans. We view this as evidence that the PSL subsidy distorts the efficient-market relationship between interest rates and delinquencies, and that loans below the PSL-qualifying threshold are riskier than those above it.

The negative slope below the PSL-qualifying threshold suggests that micro-loans (i.e., those well below the PSL-qualifying threshold) are even riskier than those just below the threshold. To evaluate the relative riskiness of different loan sizes, we estimate a version of equation (1) in which we interact the cohort effects with two dummy variables, the first of which identifies whether a loan is below the PSL-qualifying threshold in the year in which it is made, and the second which identifies whether a loan is below one-half the PSL-qualifying threshold in the year in which it is made (this is to identify the impact of being a micro loan).

Table 5 shows the estimated unconditional mean and cohort effects (cohort-specific deviations from the unconditional mean) interacted with the size dummies from this model. Panel A reports results for variable-rate mortgages, and panel B for fixed-rate mortgages.



The table reveals several interesting patterns. First, the probability of being delinquent is far higher on average for PSL-qualifying and micro loans than for those above the PSL-qualifying threshold. Second, there is an interesting time pattern to these cohort effects. Figure 8 plots the excess delinquency propensity over non-subsidized loans in each cohort (combining the unconditional mean and the cohort effect) for both PSL-qualifying and micro loans. Variable-rate and fixed-rate cohort effects are weighted by the issuance of each type of mortgage. In every one of the cohort-years in the data, PSL-qualifying loans as well as micro loans have a far higher propensity to be delinquent. There is also an interesting pattern in these excess propensities, namely that they are lower at the beginning of the sample period, increasing from roughly the middle of the sample period until two years prior to the end of the sample period, and subsequently declining.

We overlay a measure of the tightness of the PSL constraint in each cohort-year on this plot, constructed as the negative of the (log) ratio of the nominal PSL-qualifying threshold deflated by house price appreciation. The PSL-qualifying threshold is increased periodically, and when it is raised by more than the increase in house prices, the constraint is effectively looser. Conversely, if the PSL-qualifying threshold remains at the same nominal level when house prices rise substantially, the constraint is more binding. Figure 8 shows that the pattern of excess PSL delinquency propensities roughly tracks the tightness of the PSL constraint. During the late 1990s, excess delinquency propensities were declining as the PSL constraint became less binding, while during the 2000s excess delinquency propensities trended up as rising house prices tightened the PSL constraint.

To interpret these results, one should keep in mind two points. First, results for the last few years of the sample period may be distorted by the fact that recent loans may not yet have experienced delinquencies by the end of the sample period. Second, as Table 4 shows, while still substantial, PSL-qualifying loans are a smaller fraction of the mortgage book in the late 2000s. Nevertheless, we do conclude that there is substantial evidence that small subsidized loans have delinquency risk over and above larger unsubsidized loans which cannot be accounted for by their interest rates. This effect does appear to vary with the tightness of the PSL constraint, although overall, the excess default propensities appear to

have been increasing over time.

## 4.2 Change in the Classification of Non-Performing Assets

The discussion on regulation earlier noted another relevant change that took place over our sample period: as of March 31, 2004 for banks, and March 31, 2005 for HFCs, the classification of “non-performing asset” (or NPAs) was changed to 90 days past due from the previous time period of 180 days past due. This regulatory reclassification of 90-day delinquencies, and the associated implications of this change for provisioning requirements may also have contributed to the unusually low delinquency rates seen in Figure 7 for cohorts of loans issued after this change. Of course, this also raises the important question of whether our previous results using 90-day delinquencies are confirmed using data on 180-day delinquencies – a plausible model of behavior is that a mortgage provider might care more about “official” NPAs (rather than delinquencies of a shorter term than the regulatory minimum) as these have tangible balance sheet implications. Another important question that arises here is whether the regulatory re-classification of NPAs had other impacts on behavior such as an increased emphasis on monitoring shorter-term delinquencies (say 30 days past due), as any reduction in the minimum delinquency period might be expected to feed through to the earlier monitoring of mortgage default risk.

To answer the first of these questions, we re-estimate the model with 180-day delinquencies on the left-hand side replacing 90-day delinquencies. The online empirical appendix to the paper shows that while, as we might have expected, the average delinquency rate is lower when we consider 180-day delinquencies, the pattern of the cohort-time fixed effects are consistent with those found using 90-day loans. This provides reassurance that our earlier results are not simply driven by the use of a variable that is perhaps less immediately important (prior to 2004-5) to the mortgage provider.

To answer the second question, we evaluate the expected loss given a delinquency before and after the regulatory reclassification. This expected loss is the product of the probability of experiencing a delinquency and the loss given delinquency. Table 6 looks at the

first of these two elements, computing transition probabilities of loans that hit the 30-day delinquency threshold to the 90-day delinquency mark, as well as the transition probability of 90-day delinquencies to the 180-day delinquent mark. The table shows that across the entire sample period, 22.7% (22.8%) of 30-day (90-day) delinquent loans in the 10,000 loan sample eventually become 90 days (180 days) delinquent.

As we are unable to publicly identify whether the mortgage provider is a bank or an HFC, we use the earlier RBI implementation date of 31 March 2004 as the date of the regulatory change, to cover all possibilities. When we look separately at the pre-April 2004 period for the 30-day delinquencies, the transition probability is 29%, which is almost twice as high as the post-March 2004 transition probability of 14.9%, and the reduction, of 14.1% is highly statistically significant. Clearly, following the change in the definition of NPAs to the shorter 90-day limit, the mortgage provider substantially reduced this transition probability, potentially by exerting effort to pursue borrowers more aggressively. The 90-day to 180-day transition probability also reduces following the 2004 reclassification, but by a much smaller 2.3%, suggesting that once the loan becomes classified as an NPA, there are relatively fewer incentives to take action. Another possibility, of course, is that the loans reaching that point are simply very difficult to collect on despite exertions of effort.

To better understand the magnitude of loss given delinquency, we acquire a sample of 10,000 loans from the total population of loans. As our focus is to understand the determinants of mortgage risk, we randomly sample 2,500 fixed-rate and 2,500 variable-rate loans from the set of 90-day delinquent loans, and then draw 2,500 loans randomly (without replacement) from both fixed rate and variable rate loans once this first set of delinquent loans has been drawn. In each sub-sample of 2,500 loans, we make sure that we sample an equal number (1,250) from the early period in the data (disbursed prior to January 2000) and the later period (disbursed between January 2000 and December 2004). Table 7 verifies that this 10,000 loan sample has statistically indistinguishable characteristics from the population of loans from which we draw. For each one of these 10,000 loans, we are able to track the full payment history time-series, as well as deviations from contracted repayments. We can compute the latter as we are also given the equated monthly installment (EMI) for each of

these loans in each month, which is the expected monthly principal repayment plus interest amount.

For each loan in the sample, we construct a measure of losses accrued over time. To do so, we accumulate payments and EMI over time, and compute the “cumulative installment deficit” (or CID) as  $\text{Min}(0, \text{cumulative payment} - \text{cumulative EMI}) / \text{EMI}$ . This measure takes the value of zero if monthly payments exceed or equal the EMI, and is negative otherwise, indicating when borrowers are in arrears. The cumulation ensures that if overpayments are made to redress arrears, these are allowed to push the measure towards zero. The division by EMI puts the cumulative installment deficit into units of required monthly payments.

Figure 9 plots the average CID in event time around 30-, 90-, and 180-day delinquencies. That is, the first time the loans are classified as hitting these thresholds is date 0 on the plot. The figure shows that 90-day delinquencies, for loans that do not go on to be 180 days delinquent, are nevertheless costly for the mortgage provider, as it appears to take over a year for the CID to return to zero. For 180-day delinquent loans, on average, it appears that there is a cumulative loss after 12 months of hitting the threshold of roughly 5 months’ EMI – and this rough calculation does not take into account the increased mandatory provisioning requirements against such loans. Another product of this analysis, therefore, is that it quantifies the financial impacts of these payment delinquencies, and shows that they are substantial.

Figure 10 plots the CID measure before and after the regulatory changes to the definition of NPAs, and Table 8 shows the event-time information on these measures with associated standard errors. The measure is cross-sectionally demeaned by both cohort-year and calendar-year, to ensure that we are not picking up cohort or macroeconomic effects. We call the resulting abnormal monthly CID the AMCID, and the figure shows that following the regulatory change, the AMCID both before, and especially after, 30- and 90-day delinquencies is substantially lower. As we saw in the analysis of transition probabilities, the behavior of the AMCID computed using 30-day delinquencies as the 0 date is noteworthy – it appears that the mortgage provider seems to pay greater attention to such early warning signs of future arrears following the regulatory change, and the figure shows that

the ( $t$  to  $t + 12$ ) loss to 30-day delinquencies reduces by 0.79 months – this is substantial when compared with the cumulative level ( $t - 12$  to  $t + 12$ ) of this loss, of approximately 1.5 months’ EMI.

Taken together, a simple change in the regulatory definition of NPAs to a shorter length of delinquency appears to have generated significant impacts on the expected loss given delinquency of the mortgage provider. The impacts appear to be felt in reductions in the probability of delinquency, as well as in the eventual loss given delinquency, and strongly suggest a significant change in mortgage provider behavior in relation to borrowers in arrears. While it is difficult to generalize from findings from one country, these results do suggest that even seemingly innocuous changes in regulatory definitions can have important impacts on mortgage risk.

## 5 Conclusion

The Indian regulatory and macroeconomic environment has changed dramatically during the last two decades. A fast-developing housing finance system has coped with significant variation in default rates and interest rates, and regulatory changes in the incentives to originate mortgages in general, and small loans in particular. We have presented evidence that regulation may have contributed to a surge in delinquencies during the early 2000s, that subsidies for low-cost housing distorted the efficient markets relationship between interest rates and subsequent delinquencies, and that changes to the definition of non-performing assets impacted behavior in response to early evidence of payment delinquencies. Our paper contributes to the growing body of literature on the impacts of regulators and regulatory norms on risks in financial markets.

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**Table 1: Indian Macroeconomic Statistics - 1985 through 2010**

Real GDP and CPI Inflation are computed as the difference in levels as of the end of the given calendar year. Interest rates (government yields and prime rate) are computed as the average across all days (ten year government yield series) or month-ends (one year government yield and prime rate series) in each calendar year. Aggregate real home price appreciation is computed as follows. First, nominal home price appreciation is computed by loan origination location as the change in annual median home value for loans originated in that location. Aggregate nominal home price appreciation is then computed from the loan origination location home price appreciation using the number of loans disbursed by location as weights. The series is converted from nominal to real using All India CPI inflation reported by the World Bank. This method of computation is robust to shifts in loan origination between locations with differing housing costs.

Variable:	Real GDP Growth	Aggregate Real Home Price Appreciation	CPI Inflation	Yield on One Year Indian Government Bonds	Yield on Ten Year Indian Government Bonds	Indian Prime Lending Rate
Source:	World Bank	Lender Data, World Bank	World Bank	CMIE Business Beacon	Global Financial Database	Global Financial Database
1985	5.23%		5.56%		8.98%	16.50%
1986	4.77%		8.73%		9.80%	16.50%
1987	3.96%		8.80%		10.15%	16.50%
1988	9.64%		9.89%		10.66%	16.50%
1989	5.95%		6.16%		11.59%	16.50%
1990	5.53%		8.97%		12.46%	16.50%
1991	1.06%		13.87%		12.88%	17.88%
1992	5.48%		11.79%		13.61%	18.92%
1993	4.77%	-6.90%	6.36%		13.21%	16.25%
1994	6.65%	1.07%	10.21%	10.00%	13.44%	15.00%
1995	7.57%	1.39%	10.22%	12.48%	13.85%	15.50%
1996	7.56%	2.57%	8.98%	12.49%	14.03%	15.96%
1997	4.05%	5.62%	7.16%	9.01%	12.74%	13.83%
1998	6.19%	-5.27%	13.23%	8.95%	12.59%	13.54%
1999	7.39%	5.65%	4.67%	10.26%	12.28%	12.54%
2000	4.03%	6.96%	4.01%	10.00%	11.51%	12.25%
2001	5.22%	3.17%	3.68%	8.06%	10.01%	12.50%
2002	3.77%	1.68%	4.39%	6.19%	7.67%	12.00%
2003	8.37%	14.99%	3.81%	5.05%	6.16%	11.46%
2004	8.28%	21.61%	3.77%	4.93%	6.46%	10.92%
2005	9.32%	20.26%	4.25%	5.75%	7.50%	10.75%
2006	9.27%	19.01%	5.80%	6.78%	8.19%	11.19%
2007	9.82%	21.53%	6.37%	7.59%	8.50%	13.02%
2008	4.93%	9.96%	8.35%	7.98%	8.66%	13.31%
2009	9.10%	0.09%	10.88%	4.45%	7.66%	12.19%
2010	8.81%	-1.38%	10.00%	5.98%	8.45%	11.00%

**Table 2: Summary Statistics on Loan Characteristics by Disbursal Year**

This table provides year wise means (Panel A) and standard deviations (Panel B) of important characteristics for the more than 1.2 million mortgage loans disbursed by the lender. Cohort delinquency rates are computed as the annual probability that an outstanding and not-yet-90-day-delinquent loan experiences a 90 day delinquency. This probability is computed separately for each disbursal-year cohort and calendar year. The delinquency rate below represents the time-series average across calendar year estimates for each disbursal-year cohort. Statistics for fixed rate disbursals are removed for the years 2008 through 2010, as fixed rate disbursals account for well under one percent of disbursals (by count or value) in each of these years. Similarly, cohort 90-day delinquency rate is omitted for loans disbursed after 2007 as these loans have not been around long enough to reliably estimate a delinquency rate.

**A: Cross-Sectional Means**

	Initial Interest Rate		Loan Term (Years)		Loan-Cost Ratio		Loan-Income Ratio		Cohort 90-Day Delinquency Rate	
	Variable	Fixed	Variable	Fixed	Variable	Fixed	Variable	Fixed	Variable	Fixed
1995	15.22%	15.00%	13.96	11.66	0.58	0.54	3.73	3.52	1.70%	2.27%
1996	16.39%	16.14%	13.21	10.89	0.57	0.54	3.69	3.45	1.98%	2.56%
1997	15.54%	15.25%	13.18	10.38	0.58	0.55	3.69	3.38	1.76%	2.79%
1998	14.45%	14.09%	13.08	10.06	0.61	0.57	3.67	3.28	1.84%	3.12%
1999	13.58%	13.39%	12.88	10.63	0.64	0.61	3.62	3.31	1.78%	4.38%
2000	12.58%	12.83%	12.95	10.55	0.67	0.67	3.58	3.20	2.13%	4.58%
2001	11.78%	11.76%	12.72	10.23	0.68	0.64	3.56	3.23	2.16%	5.27%
2002	10.92%	10.82%	13.15	10.03	0.70	0.64	3.49	3.21	2.53%	4.63%
2003	10.68%	9.41%	12.88	12.76	0.72	0.65	3.45	3.54	2.36%	2.20%
2004	10.82%	8.13%	14.07	15.13	0.73	0.71	3.65	3.75	2.18%	0.91%
2005	10.42%	8.83%	15.16	15.17	0.74	0.69	3.75	3.72	1.75%	1.26%
2006	10.85%	10.45%	15.23	15.59	0.73	0.70	3.74	3.69	1.53%	1.12%
2007	11.03%	12.26%	15.03	14.68	0.73	0.68	3.75	3.58	1.18%	1.43%
2008	10.79%		15.38		0.72		3.78			
2009	9.51%		14.31		0.71		3.72			
2010	8.39%		15.59		0.73		3.84			

**B: Cross-Sectional Standard Deviations**

	Initial Interest Rate		Loan Term (Years)		Loan-Cost Ratio		Loan-Income Ratio	
	Variable	Fixed	Variable	Fixed	Variable	Fixed	Variable	Fixed
1995	0.94%	1.13%	2.51	4.24	0.18	0.20	0.47	0.71
1996	1.28%	1.53%	2.73	4.26	0.18	0.20	0.49	0.74
1997	0.84%	1.22%	2.72	4.49	0.18	0.20	0.51	0.83
1998	0.71%	1.09%	2.81	4.69	0.18	0.20	0.51	0.86
1999	0.51%	0.77%	3.00	4.52	0.18	0.19	0.52	0.80
2000	1.21%	0.85%	3.61	4.57	0.18	0.19	0.57	0.85
2001	1.06%	0.97%	3.97	4.56	0.18	0.24	0.61	0.83
2002	1.46%	0.92%	4.43	4.63	0.19	0.24	0.70	0.81
2003	2.08%	0.89%	4.85	4.77	0.19	0.26	0.78	0.67
2004	2.04%	0.60%	4.97	4.55	0.18	0.21	0.72	0.59
2005	1.73%	0.48%	4.92	4.52	0.18	0.22	0.68	0.60
2006	1.24%	0.76%	4.95	4.48	0.18	0.22	0.70	0.63
2007	0.67%	1.00%	4.41	4.78	0.18	0.23	0.69	0.71
2008	0.59%		4.57		0.18		0.70	
2009	0.77%		5.00		0.18		0.72	
2010	0.37%		4.55		0.17		0.64	

**Table 3: Delinquency Model**

This table presents coefficient estimates and standard errors from estimates of equation (1) in the paper. The estimation takes place in two stages. First, cross-sectional estimates are produced for each year. Coefficients below are produced from the cross-sectional estimates by classical minimum distance. Standard errors are given in italics below the corresponding coefficients, and are computed by bootstrapping calendar years. Coefficients that are statistically significant at a 5% two-sided level are in bold type. The null hypothesis is that the macroeconomic effects equal one and all other coefficients equal zero. All coefficients (except macroeconomic effects  $z(t)$ ) and associated standard errors are multiplied by 100 for readability.

	<b>Variable Rate</b>	<b>Fixed Rate</b>
A: Loan and Borrower Characteristics		
Loan Characteristics:		
Initial Interest Rate	<b>0.410</b> <i>0.046</i>	<b>0.375</b> <i>0.052</i>
Regional Log Home Price Appreciation Since Disbursal	<b>-1.186</b> <i>0.282</i>	<b>-2.490</b> <i>0.735</i>
Log Loan to Income Ratio (winsorized at 1st, 99th)	<b>0.608</b> <i>0.067</i>	<b>1.222</b> <i>0.061</i>
Log Loan to Cost Ratio	<b>1.281</b> <i>0.068</i>	<b>2.716</b> <i>0.138</i>
Dummy: Usually Paid by Salary Deduction	<b>-1.740</b> <i>0.089</i>	<b>-3.020</b> <i>0.165</i>
Dummy: Loan administered through employers	<b>-0.275</b> <i>0.077</i>	<b>-0.388</b> <i>0.205</i>
Dummy: Loan is a Refinancing	<b>0.464</b> <i>0.102</i>	<b>0.160</b> <i>0.139</i>
Dummy: Loan is for a Home Extension	<b>-0.181</b> <i>0.044</i>	<b>-0.393</b> <i>0.093</i>
Dummy: Loan is for a Home Improvement	<b>0.322</b> <i>0.094</i>	<b>0.380</b> <i>0.145</i>
Dummy: Tranched Issuance	<b>-0.475</b> <i>0.133</i>	<b>-0.282</b> <i>0.442</i>
Dummy: 6 to 10 Year Loan	<b>0.188</b> <i>0.067</i>	<b>1.132</b> <i>0.189</i>
Dummy: 11 to 15 Year Loan	<b>0.683</b> <i>0.082</i>	<b>1.729</b> <i>0.228</i>
Dummy: 16 Year+ Loan	<b>1.440</b> <i>0.170</i>	<b>1.605</b> <i>0.197</i>
Dummy: Year of Loan Issuance	<b>-2.412</b> <i>0.159</i>	<b>-3.905</b> <i>0.376</i>
Piecewise-Linear Loan Size Controls		
Log(Loan Amount / PSL Threshold at Loan Disbursal), Below PSL Threshold	<b>-0.899</b> <i>0.127</i>	<b>-1.673</b> <i>0.094</i>
Log(Loan Amount / PSL Threshold at Loan Disbursal), Above PSL Threshold	<b>-0.195</b> <i>0.100</i>	<b>0.398</b> <i>0.195</i>

*Continued on Next Page*

	<b>Variable Rate</b>	<b>Fixed Rate</b>
Borrower Characteristics:		
Log Number of Dependents	<b>-0.125</b> <i>0.044</i>	<b>0.226</b> <i>0.070</i>
Male Borrower	<b>0.183</b> <i>0.026</i>	<b>0.490</b> <i>0.055</i>
Married Borrower	<i>0.054</i> <i>0.042</i>	<i>0.145</i> <i>0.091</i>
Borrower age 36-45	<b>0.077</b> <i>0.014</i>	<i>0.115</i> <i>0.062</i>
Age 46 and up	<b>0.221</b> <i>0.044</i>	<b>0.220</b> <i>0.075</i>
Dummy: Repeat Borrower	<b>0.399</b> <i>0.122</i>	<b>0.849</b> <i>0.129</i>
Dummy: Qualification Missing or Unidentified	<b>-0.137</b> <i>0.069</i>	<i>-0.142</i> <i>0.079</i>
Dummy: HSC Equivalent	<b>-0.407</b> <i>0.067</i>	<b>-0.858</b> <i>0.081</i>
Dummy: BA Equivalent	<b>-0.650</b> <i>0.093</i>	<b>-1.243</b> <i>0.089</i>
Dummy: Post-Grad Equivalent	<b>-1.025</b> <i>0.084</i>	<b>-1.799</b> <i>0.110</i>
Dummy: Finance-Related Qualification	<b>0.177</b> <i>0.029</i>	<b>0.210</b> <i>0.065</i>
Cohort Fixed Effects?	Yes, Appendix Table A1	
Annual Macroeconomic Effects?	Yes, Appendix Table A1	
21 Branch Dummies?	Yes	
Monthly Fixed Effects?	Yes	

**Table 4: Share of Loan Disbursals Above and Below Priority Sector Lending (PSL) Threshold Values**

The share of loan disbursals above and below the PSL threshold and 0.5 times the PSL threshold are given as the share of the total value of loans disbursed in the given year. The PSL threshold levels are sporadically reset (October 22, 1997, October 29, 1999, April 29, 2003, October 26, 2004, and July 2, 2007 are reset dates between 1995 and 2010). The regulatory source documents are detailed in the accompanying appendix on Prudential Mortgage Regulation in India. The distribution of fixed rate mortgage issuances after 2007 is not shown due to the limited extent of fixed rate lending in these years.

	Variable Rate Share of Disbursals		Variable Rate Mortgages			Fixed Rate Mortgages		
	By Count	By Value	Above PSL Threshold	Below PSL Threshold	Below 0.5X PSL Threshold	Above PSL Threshold	Below PSL Threshold	Below 0.5X PSL Threshold
1995	37.86%	42.98%	31.60%	68.40%	30.29%	29.01%	70.99%	37.78%
1996	47.45%	51.78%	36.95%	63.05%	27.07%	35.89%	64.11%	32.08%
1997	55.29%	60.84%	40.09%	59.91%	24.43%	38.27%	61.73%	30.39%
1998	59.04%	66.78%	26.67%	73.33%	40.06%	20.91%	79.09%	49.65%
1999	65.55%	71.32%	27.79%	72.21%	37.43%	21.80%	78.20%	45.77%
2000	75.70%	81.65%	23.36%	76.64%	47.66%	16.58%	83.42%	59.91%
2001	75.32%	82.31%	28.05%	71.95%	42.50%	17.49%	82.51%	61.95%
2002	84.40%	89.83%	32.52%	67.48%	39.23%	15.49%	84.51%	64.97%
2003	94.14%	94.16%	34.44%	65.56%	38.51%	34.88%	65.12%	40.57%
2004	84.51%	79.97%	35.35%	64.65%	34.28%	51.60%	48.40%	21.43%
2005	90.40%	92.09%	37.43%	62.57%	33.57%	24.81%	75.19%	45.40%
2006	90.44%	92.87%	56.03%	43.97%	21.21%	35.09%	64.91%	34.43%
2007	95.76%	97.72%	59.76%	40.24%	17.10%	35.61%	64.39%	39.08%
2008	99.44%	99.80%	60.32%	39.68%	15.53%			
2009	99.87%	99.97%	64.58%	35.42%	13.19%			
2010	99.97%	99.99%	66.72%	33.28%	9.69%			

**Table 5: Delinquency Model With Cohort X Size Effects**

This table presents coefficient estimates and standard errors from estimates of equation (1) in the paper, modified to include interactions between size dummies and cohort effects. See notes to Table 3 for a brief description of the estimation procedure and control variables. Standard errors are given in italics below the corresponding coefficients, and are computed by bootstrapping calendar years. The null hypothesis is that all unconditional averages, cohort-specific, and size effects are zero. Coefficients are in bold type where this null is rejected at a 95% two-sided confidence level. Coefficients and associated standard errors are multiplied by 100 for readability. Panel A presents variable rate mortgage results, and Panel B, fixed.

	<b>Delinquency Rate for Loans Above PSL Threshold</b>	<b>Additional Delinquency Fixed Effect for Loans Below PSL Threshold</b>	<b>Further Delinquency Fixed Effect for Loans Below 0.5 X PSL Threshold</b>
A: Variable Rate Mortgages			
Unconditional Averages			
	<b>1.348</b>	<b>0.325</b>	<b>0.622</b>
	<i>0.064</i>	<i>0.037</i>	<i>0.056</i>
Cohort-Specific			
1995	<b>0.824</b>	-0.344	<b>-0.382</b>
	<i>0.367</i>	<i>0.281</i>	<i>0.110</i>
1996	<b>0.771</b>	<b>-0.288</b>	<b>-0.467</b>
	<i>0.332</i>	<i>0.111</i>	<i>0.104</i>
1997	0.397	<b>-0.259</b>	<b>-0.323</b>
	<i>0.302</i>	<i>0.083</i>	<i>0.069</i>
1998	<b>0.655</b>	<b>-0.371</b>	-0.096
	<i>0.276</i>	<i>0.119</i>	<i>0.081</i>
1999	0.051	-0.108	-0.145
	<i>0.139</i>	<i>0.063</i>	<i>0.084</i>
2000	<b>0.295</b>	<b>-0.387</b>	-0.198
	<i>0.102</i>	<i>0.085</i>	<i>0.105</i>
2001	0.057	<b>-0.209</b>	-0.053
	<i>0.172</i>	<i>0.096</i>	<i>0.097</i>
2002	<b>0.334</b>	<b>0.243</b>	-0.183
	<i>0.167</i>	<i>0.096</i>	<i>0.127</i>
2003	0.221	0.328	-0.092
	<i>0.238</i>	<i>0.174</i>	<i>0.236</i>
2004	0.192	<b>0.417</b>	0.314
	<i>0.201</i>	<i>0.133</i>	<i>0.298</i>
2005	-0.451	0.310	<b>0.886</b>
	<i>0.286</i>	<i>0.169</i>	<i>0.285</i>
2006	-0.426	<b>0.336</b>	<b>0.629</b>
	<i>0.301</i>	<i>0.122</i>	<i>0.262</i>
2007	-0.463	0.303	0.423
	<i>0.332</i>	<i>0.189</i>	<i>0.236</i>
2008	-0.396	0.123	0.140
	<i>0.382</i>	<i>0.101</i>	<i>0.226</i>
2009	-0.855	0.062	-0.221
	<i>0.651</i>	<i>0.134</i>	<i>0.116</i>
2010	-1.205	<b>-0.156</b>	<b>-0.232</b>
	<i>0.703</i>	<i>0.028</i>	<i>0.056</i>
Loan and Borrower Characteristics?			Yes, Same as Table 4
Annual Macroeconomic Effects?			Yes
21 Branch Dummies?			Yes
Monthly Fixed Effects?			Yes

**Table 5: Delinquency Model With Cohort X Size Effects (Contd.)**

Panel B: Fixed rate mortgages. Cohort effects from 2008 through 2010 are ignored as the limited number of fixed rate issuances in these years makes estimation of associated cohort effects imprecise.

	<b>Delinquency Rate for Loans Above PSL Threshold</b>	<b>Additional Delinquency Fixed Effect for Loans Below PSL Threshold</b>	<b>Further Delinquency Fixed Effect for Loans Below 0.5 X PSL Threshold</b>
<b>B: Fixed Rate Mortgages</b>			
Unconditional Averages, 1995-2007			
	<b>2.075</b>	<b>0.397</b>	<b>1.310</b>
	<i>0.169</i>	<i>0.086</i>	<i>0.112</i>
Cohort-Specific			
1995	0.634	-0.056	-0.200
	<i>0.805</i>	<i>0.299</i>	<i>0.224</i>
1996	0.503	-0.186	-0.020
	<i>0.737</i>	<i>0.297</i>	<i>0.283</i>
1997	0.668	-0.272	-0.150
	<i>0.706</i>	<i>0.195</i>	<i>0.209</i>
1998	1.119	-0.582	-0.202
	<i>0.734</i>	<i>0.393</i>	<i>0.184</i>
1999	1.138	<b>-0.548</b>	-0.053
	<i>0.667</i>	<i>0.168</i>	<i>0.294</i>
2000	0.414	0.216	0.025
	<i>0.587</i>	<i>0.401</i>	<i>0.198</i>
2001	<b>1.273</b>	-0.242	-0.055
	<i>0.601</i>	<i>0.498</i>	<i>0.451</i>
2002	-0.072	0.513	0.089
	<i>1.129</i>	<i>0.787</i>	<i>0.577</i>
2003	-1.286	0.318	0.048
	<i>0.772</i>	<i>0.261</i>	<i>0.548</i>
2004	-1.361	0.522	-0.534
	<i>0.820</i>	<i>0.291</i>	<i>0.288</i>
2005	<b>-1.512</b>	0.217	0.664
	<i>0.760</i>	<i>0.184</i>	<i>0.507</i>
2006	-0.873	0.165	0.145
	<i>0.732</i>	<i>0.244</i>	<i>0.518</i>
2007	-0.647	-0.066	0.244
	<i>0.676</i>	<i>0.496</i>	<i>0.788</i>
Loan and Borrower Characteristics?			Yes, Same as Table 4
Annual Macroeconomic Effects?			Yes
21 Branch Dummies?			Yes
Monthly Fixed Effects?			Yes

**Table 6: Probability of Transition to Later Stage of Delinquency**

This table presents the probability that initial 30 and 90 day mortgage delinquencies become 90 and 180 day mortgage delinquencies respectively within six months following the initial delinquency. This transition probability is first computed for all loans with initial delinquencies in a given month, and the probabilities shown below are the time-series average of these monthly cross-sectional estimates, where the average is taken over the indicated time periods. Standard errors are given in italics and constructed by bootstrapping from the population of monthly cross-sectional estimates from before and after April 1, 2004. All coefficients are highly statistically significant.

Month Relative	Probability of 30 day Delinquency Transitioning to 90 day Delinquency		Probability of 90 day Delinquency Transitioning to 180 day Delinquency	
	Value	SE	Value	SE
For Initial Delinquencies Occurring:				
All Months (Jan 1996-Dec 2010)	22.7%	<i>0.3%</i>	22.8%	<i>0.4%</i>
Jan 1996-Mar 2004	29.0%	<i>0.5%</i>	23.9%	<i>0.6%</i>
April 2004-Dec 2010	14.9%	<i>0.4%</i>	21.6%	<i>0.6%</i>
Difference Around April 2004	-14.1%	<i>0.7%</i>	-2.3%	<i>0.9%</i>

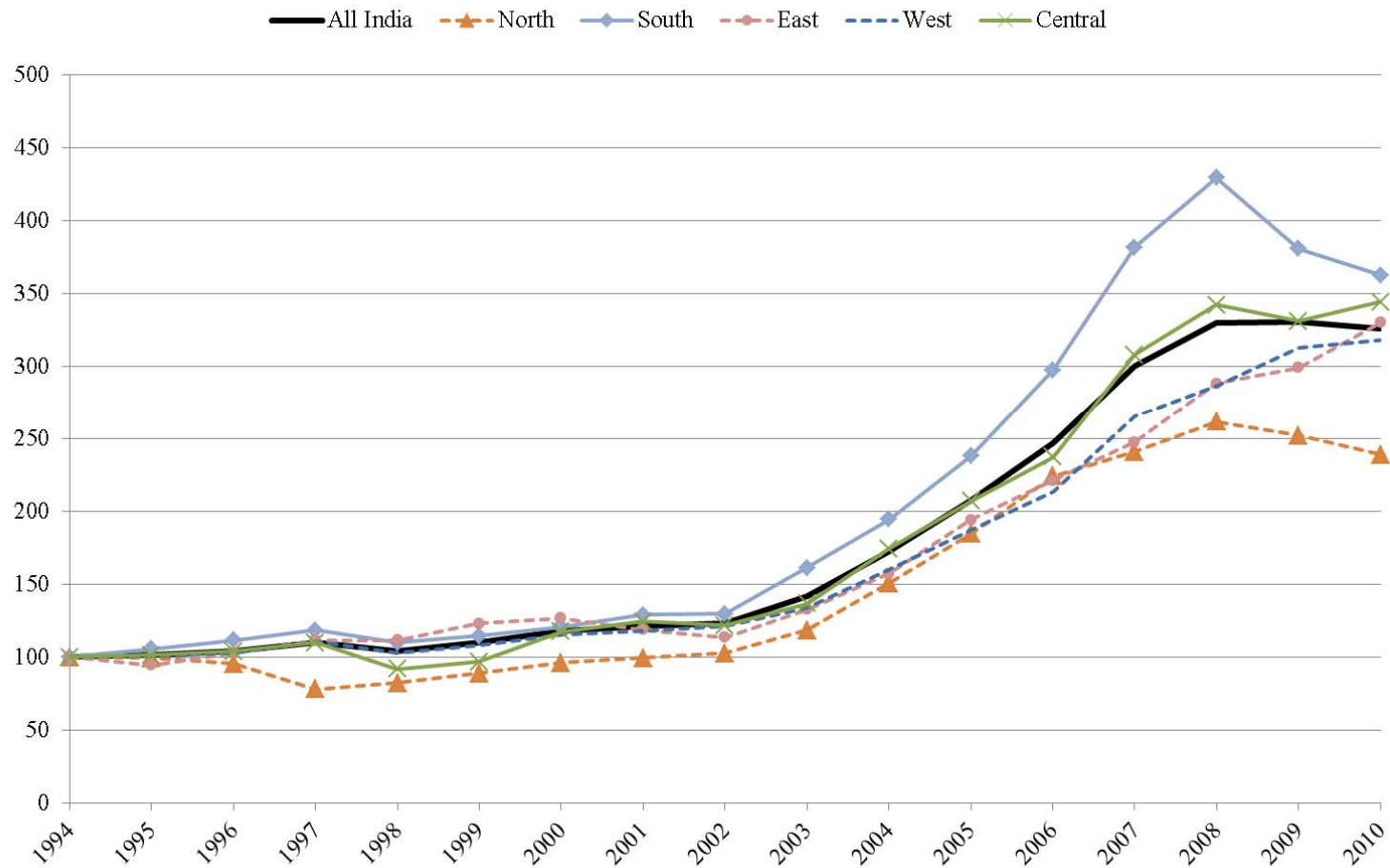


**Table 7: Loan and Borrower Characteristics, Full Dataset and Detailed 10,000 Mortgage Subsample**

The 10,000 mortgage subsample is a stratified random sample of 1,250 loans in each of eight categories. This table provides sample and full-population means for each of these categories. The eight categories are formed by three splits of the data ( $8=2^3$ ) based on whether the loan is disbursed before/after January 1, 2000, is fixed or variable rate, and ultimately registers a 90 day delinquency. Borrowers with finance related qualifications are primarily those holding bachelors or masters degrees in commerce or business administration.

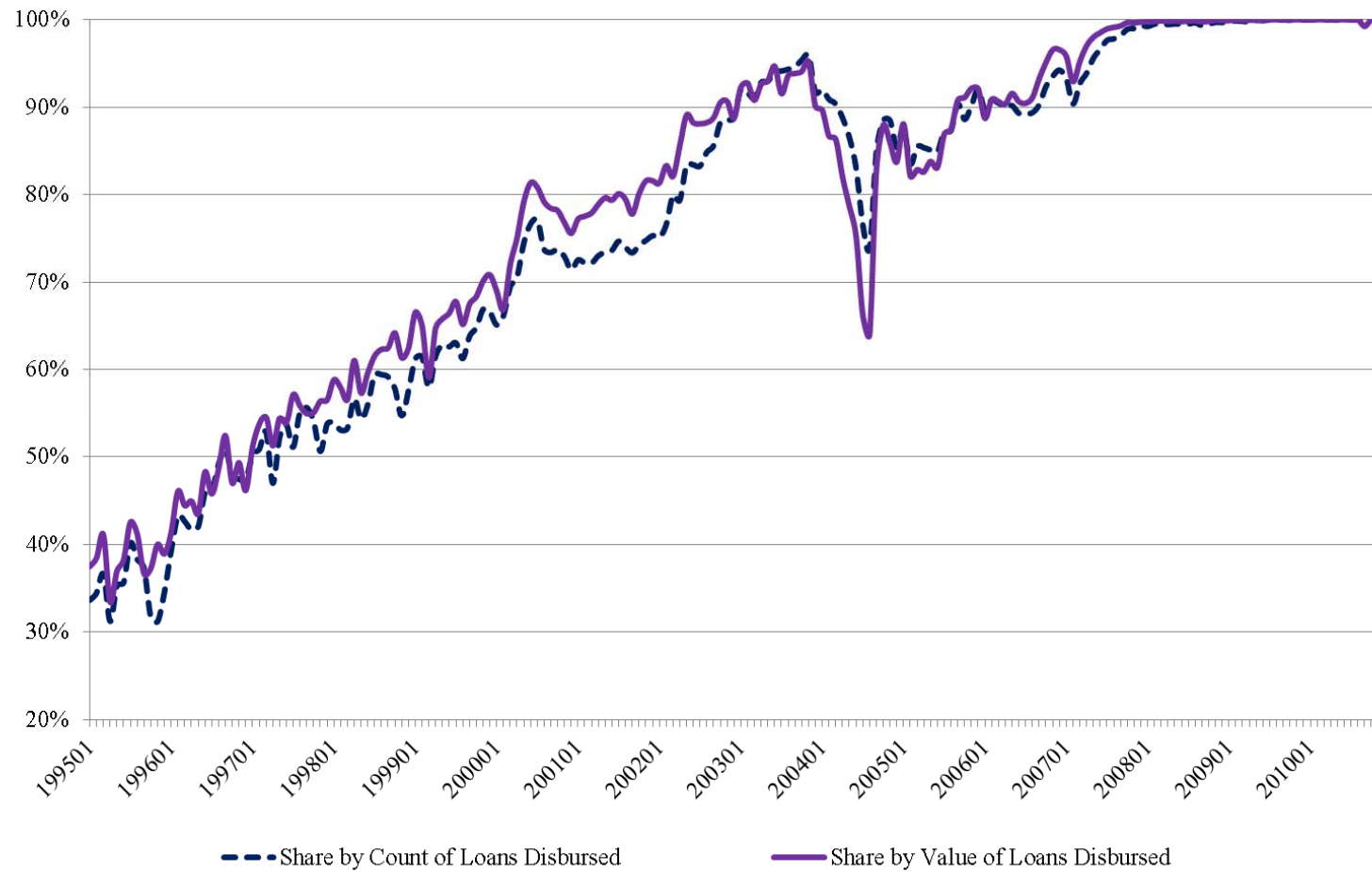
Characteristic	Mortgages With No Eventual 90 Day Delinquencies				Mortgages With Eventual 90 Day Delinquencies			
	Disbursed 1995-1999		Disbursed 2000-2004		Disbursed 1995-1999		Disbursed 2000-2004	
	Full	Subsample	Full	Subsample	Full	Subsample	Full	Subsample
Panel A: Variable Rate Mortgages								
Initial Interest Rate (%)	14.64	14.65	11.09	11.09	14.75	14.83	11.87	11.90
Loan Term (Years)	13.07	13.07	13.00	13.01	13.40	13.45	14.01	14.15
Employer Administered Loans	0.16	0.17	0.24	0.23	0.07	0.07	0.12	0.12
Loan Paid by Salary Deduction	30%	31%	23%	21%	12%	13%	10%	9%
Tranched Issuance	0%	0%	0%	0%	0%	0%	0%	0%
Refinancing	0%	0%	5%	7%	0%	0%	4%	5%
Home Extension	6%	6%	6%	8%	5%	5%	5%	5%
Home Improvement	2%	2%	12%	12%	3%	3%	12%	11%
Male Borrower	87%	87%	86%	86%	86%	87%	86%	84%
Married Borrowers	94%	94%	95%	95%	94%	93%	95%	95%
Borrower Age	38.07	38.18	39.79	39.40	37.63	37.20	39.11	38.90
Number of Dependents	1.54	1.50	1.52	1.48	1.55	1.50	1.65	1.63
Loan-Cost Ratio	0.60	0.61	0.70	0.70	0.62	0.62	0.72	0.72
Loan-Income Ratio	3.66	3.65	3.53	3.52	3.68	3.68	3.58	3.59
HSC Equivalent	18%	19%	18%	19%	17%	19%	20%	19%
BA Equivalent	36%	36%	34%	36%	36%	38%	31%	33%
Post-Grad Equivalent	16%	16%	18%	17%	13%	12%	12%	12%
Finance Related Qualification	12%	11%	13%	13%	13%	13%	11%	13%
Panel B: Fixed Rate Mortgages								
Initial Interest Rate (%)	14.65	14.63	10.74	10.78	14.75	14.72	11.69	11.75
Loan Term (Years)	10.45	10.50	11.19	10.95	11.66	11.62	11.73	12.05
Employer Administered Loans	0.00	0.00	0.16	0.15	0.00	0.00	0.04	0.04
Loan Paid by Salary Deduction	26%	28%	27%	26%	14%	12%	14%	15%
Tranched Issuance	0%	0%	0%	0%	0%	0%	0%	0%
Refinancing	0%	0%	2%	3%	0%	0%	1%	0%
Home Extension	7%	7%	7%	7%	6%	5%	6%	5%
Home Improvement	18%	20%	20%	20%	13%	14%	17%	17%
Male Borrower	85%	86%	86%	87%	87%	86%	86%	85%
Married Borrowers	94%	94%	94%	95%	94%	94%	95%	96%
Borrower Age	40.00	39.52	40.46	40.95	39.17	38.94	40.26	40.21
Number of Dependents	1.43	1.36	1.58	1.54	1.54	1.49	1.88	1.84
Loan-Cost Ratio	0.56	0.56	0.68	0.68	0.60	0.60	0.70	0.70
Loan-Income Ratio	3.35	3.35	3.31	3.29	3.47	3.46	3.38	3.42
HSC Equivalent	16%	16%	17%	17%	15%	15%	18%	18%
BA Equivalent	36%	36%	32%	30%	31%	32%	24%	24%
Post-Grad Equivalent	16%	16%	16%	16%	10%	9%	8%	8%
Finance Related Qualification	13%	14%	13%	12%	11%	13%	8%	8%

**Figure 1: CPI Adjusted House Price Appreciation Indices**

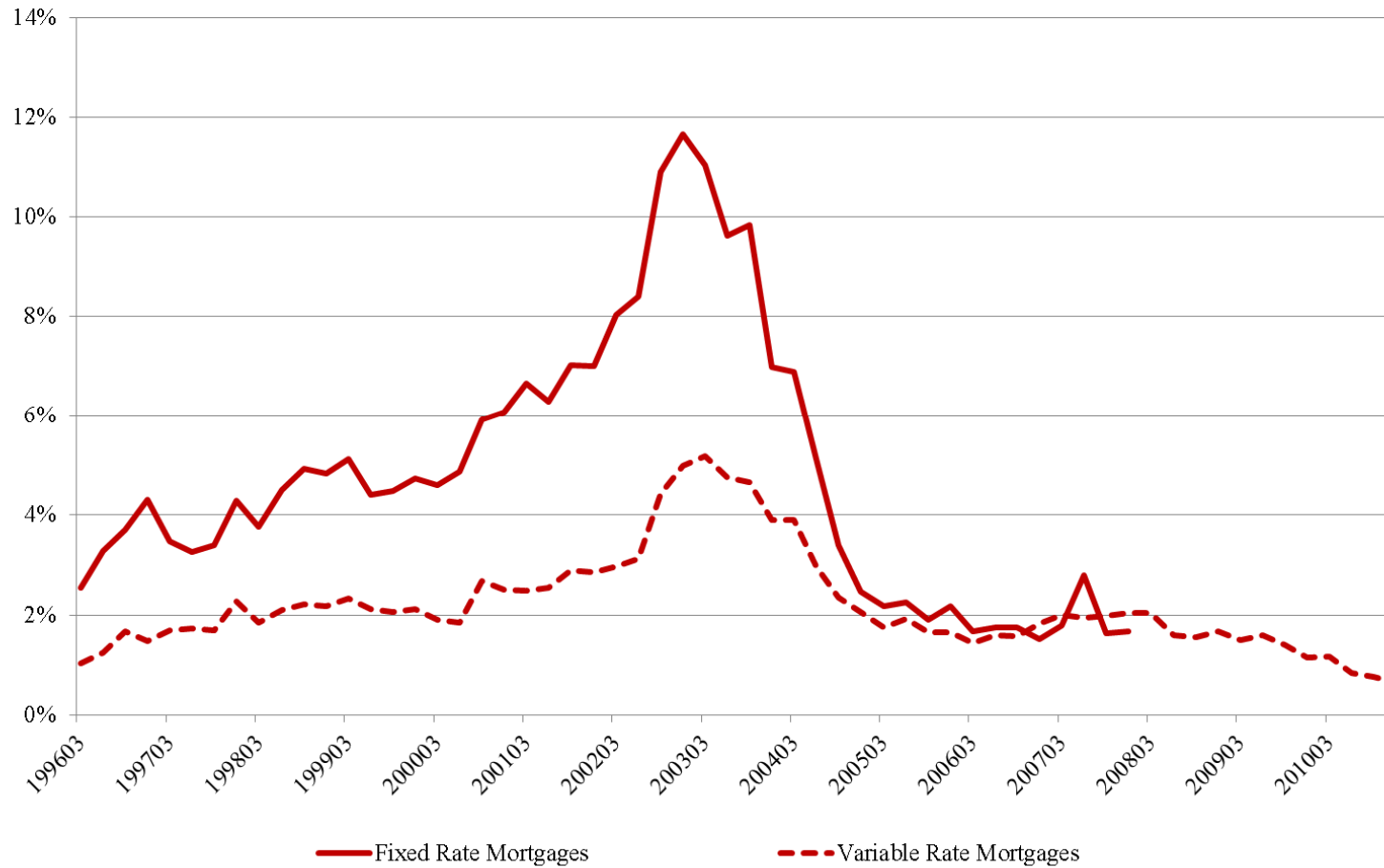


Notes: Regional (north, south, east, west, central) and all India home price appreciation are constructed as disbursal count weighted averages of home price appreciation by loan origination location. Appreciation by loan origination location is computed as the change in annual median home value corresponding to loans disbursed in that location. This method of computation is robust to shifts in loan origination between locations with differing housing costs. CPI figures used for adjustment are from the World Bank.

**Figure 2: Variable Rate Share of Mortgage Disbursals**

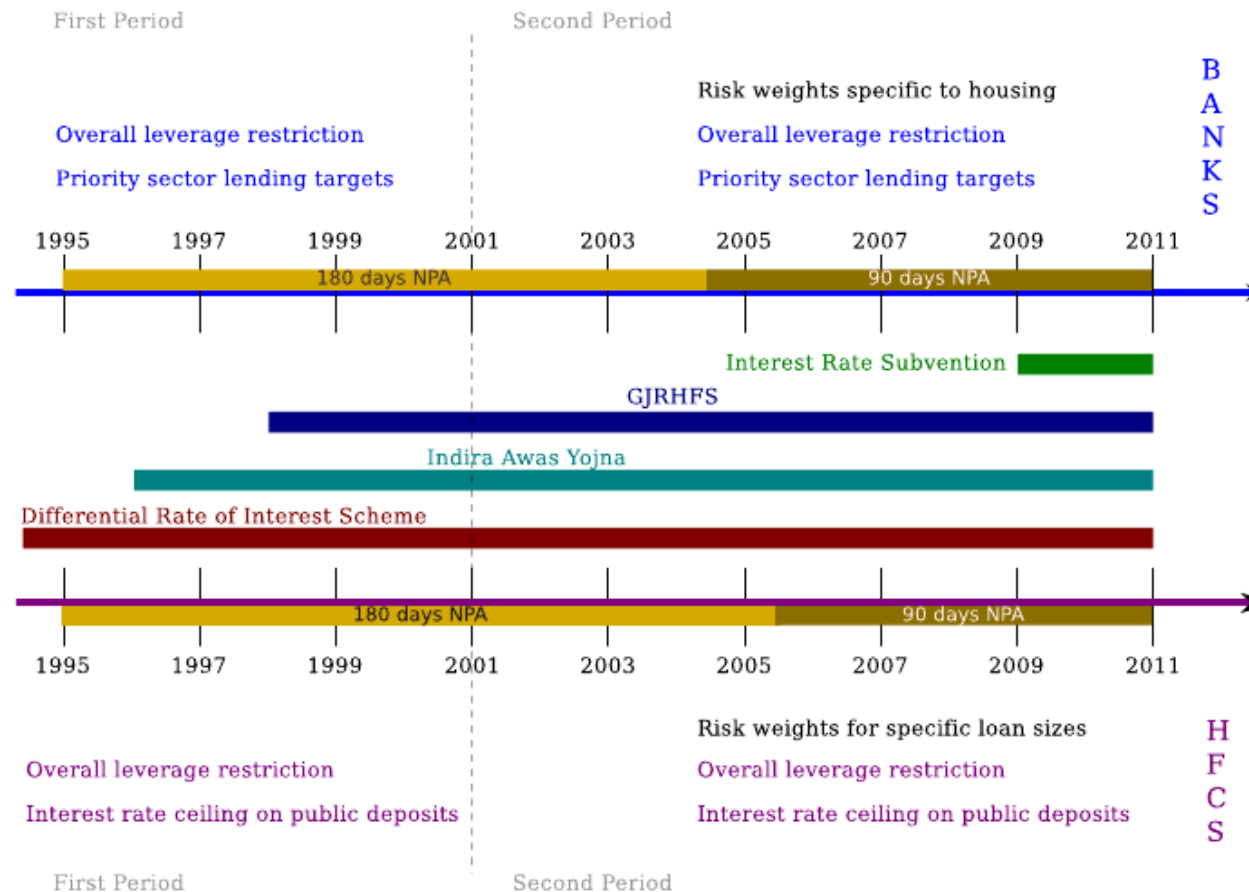


**Figure 3: Annualized Seasonally-Adjusted 90-Day Delinquency Rate**



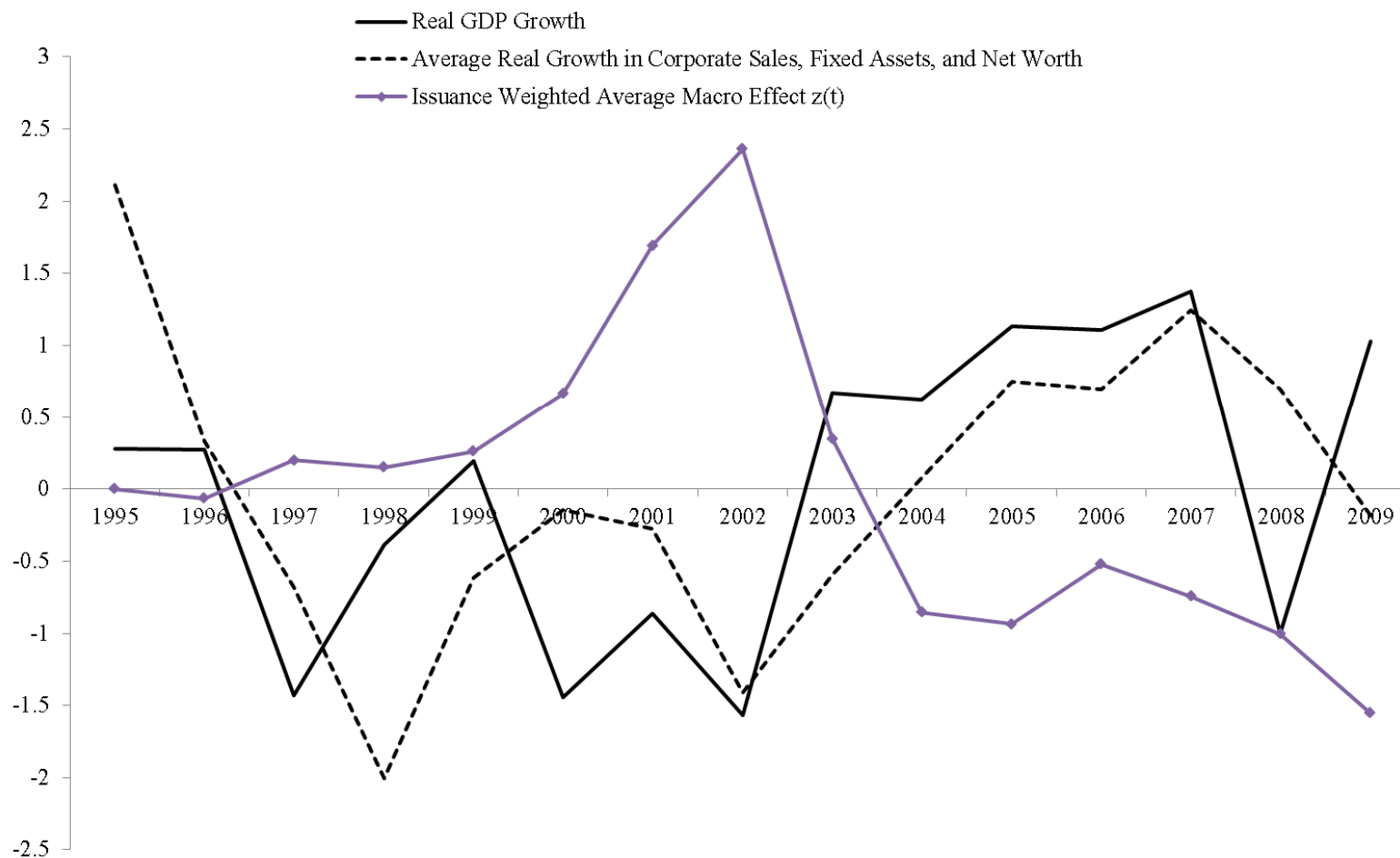
Notes: Seasonal adjustments are computed by regressing log quarterly 90 day delinquency rates (for all outstanding fixed or variable rate mortgages) on a set of year and calendar quarter dummies. The calendar quarter dummies from the log default rate regressions are exponentiated, normalized to one, and are used as scaling factors to seasonally-adjust the quarterly delinquency rates. The resulting quarterly delinquency rates (DEFQ) are annualized by the transformation  $1-(1-DEFQ)^4$ .

**Figure 4: Timeline of Indian Mortgage Regulation**



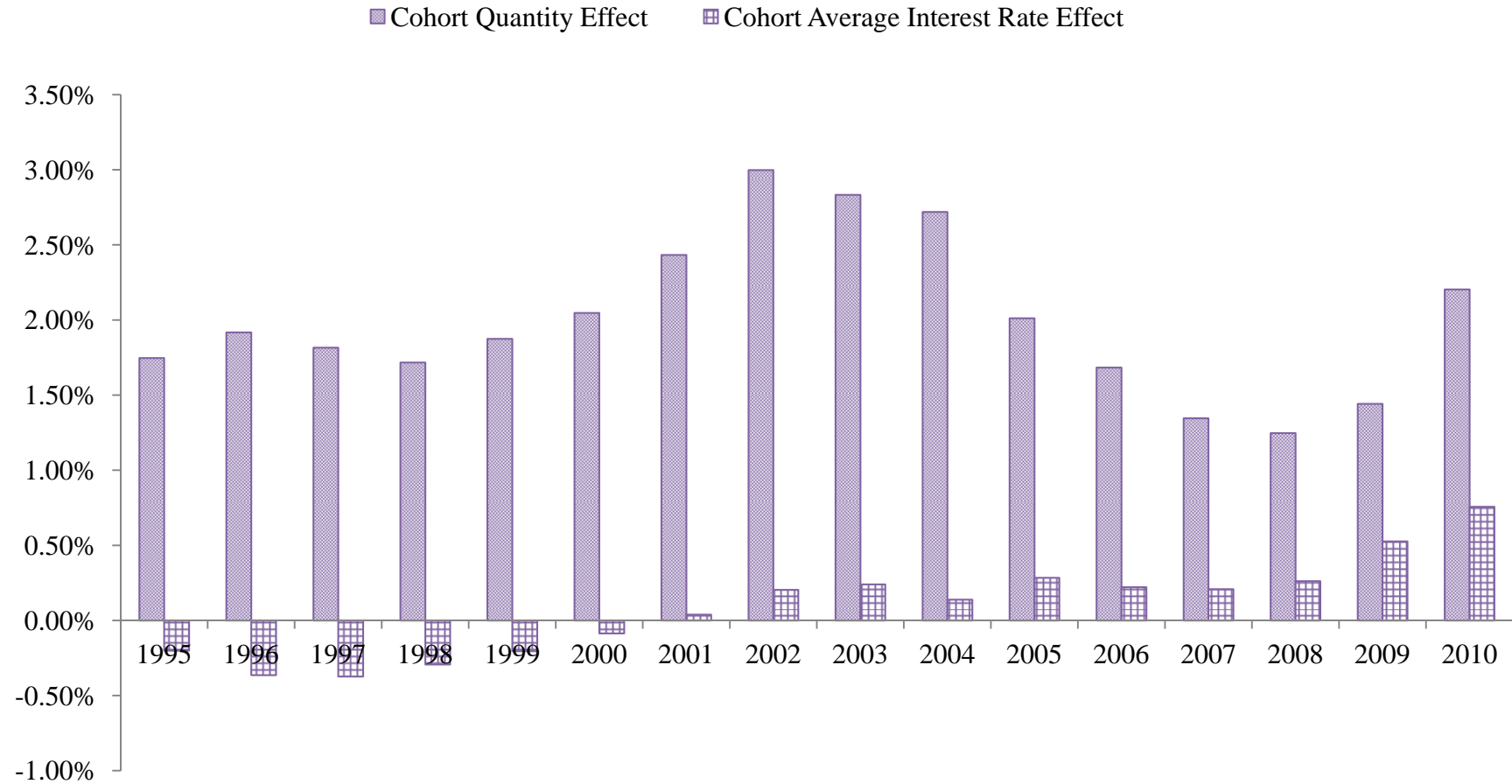
Notes: This figure summarizes regulation affecting mortgage lending in India, with the top half representing the form of regulations affecting banks and the bottom half representing the form of regulations affecting housing finance companies (HFCs). The solid bars in the middle section represent the timeline of programs affecting mortgage lending by both banks and HFCs. A division of regulations is drawn in 2001 (separating "first" and "second" periods) as that is when changing risk weights became a primary means of banking regulation in India. For further details on Indian mortgage regulation, see the Appendix on Prudential Regulation of Housing Finance in India 1995-2011.

**Figure 5: Macro Delinquency Effects and Other Indian Macroeconomic Time Series**



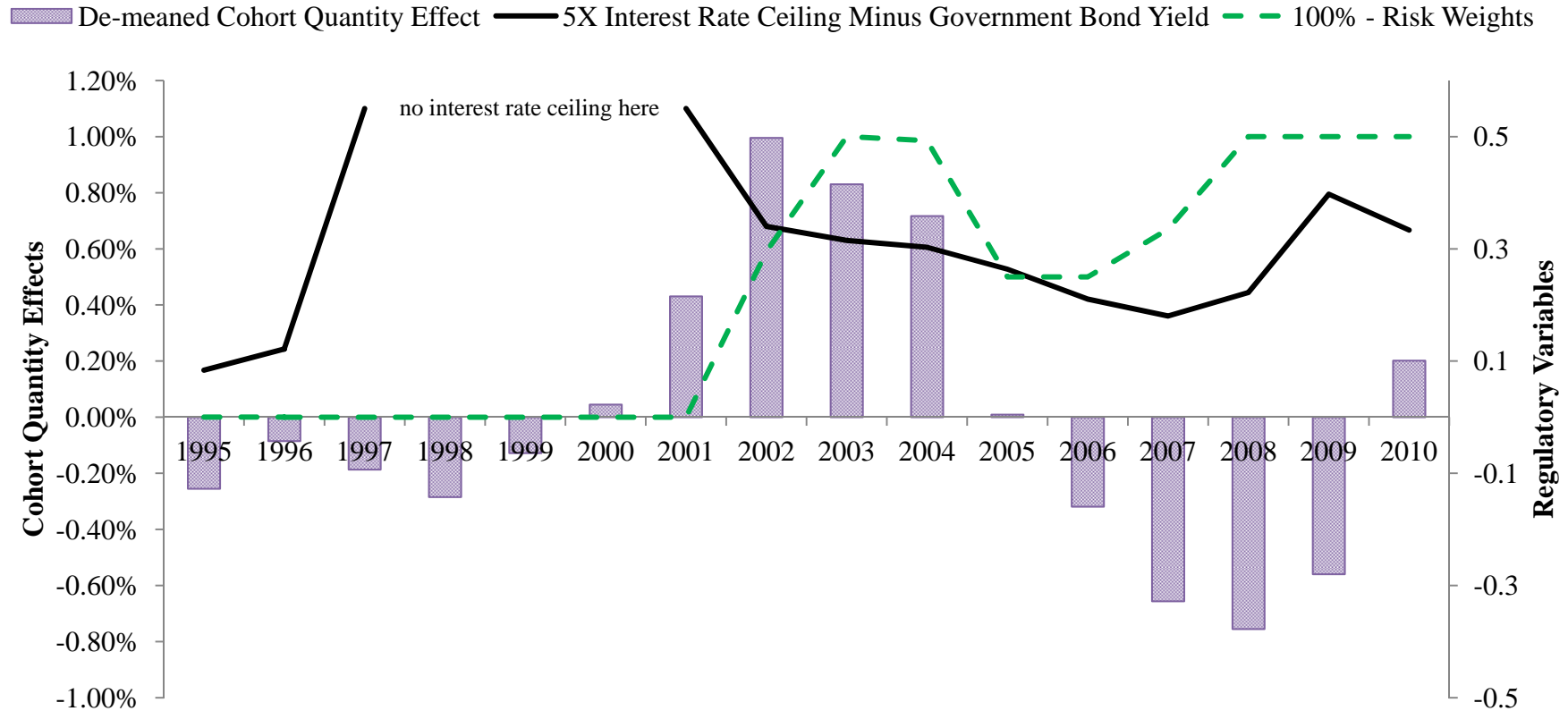
Notes: Real GDP growth is from the World Bank. Average real growth in corporate sales, fixed assets, and net worth is the average of the three constituent time series, which are taken from the Prowess database. CPI inflation (from the World Bank) is subtracted from this series. The issuance weighted average macro effect is the weighted average of the fixed rate and variable rate macroeconomic effects  $z(t)$  estimated in the delinquency model (Equation (1) in the paper), where the weights are equal to the fraction of the total value of mortgage loans disbursed that are fixed or variable rate. All variables plotted are standardized.

**Figure 6: Decomposition of Issuance Weighted Average Cohort Effects**



Notes: The cohort quantity effect and average interest rate effect represent a decomposition of the cohort effects estimated in the delinquency model (equation 1) into a component fitted to the cohort average interest rate (cohort average interest rate effect) and the residual plus mean (cohort quantity effect). The series are a weighted average of a separately applied decomposition for variable and fixed rate mortgages, where the weights for a given year are equal to the share of variable and fixed rate issuance for that cohort.

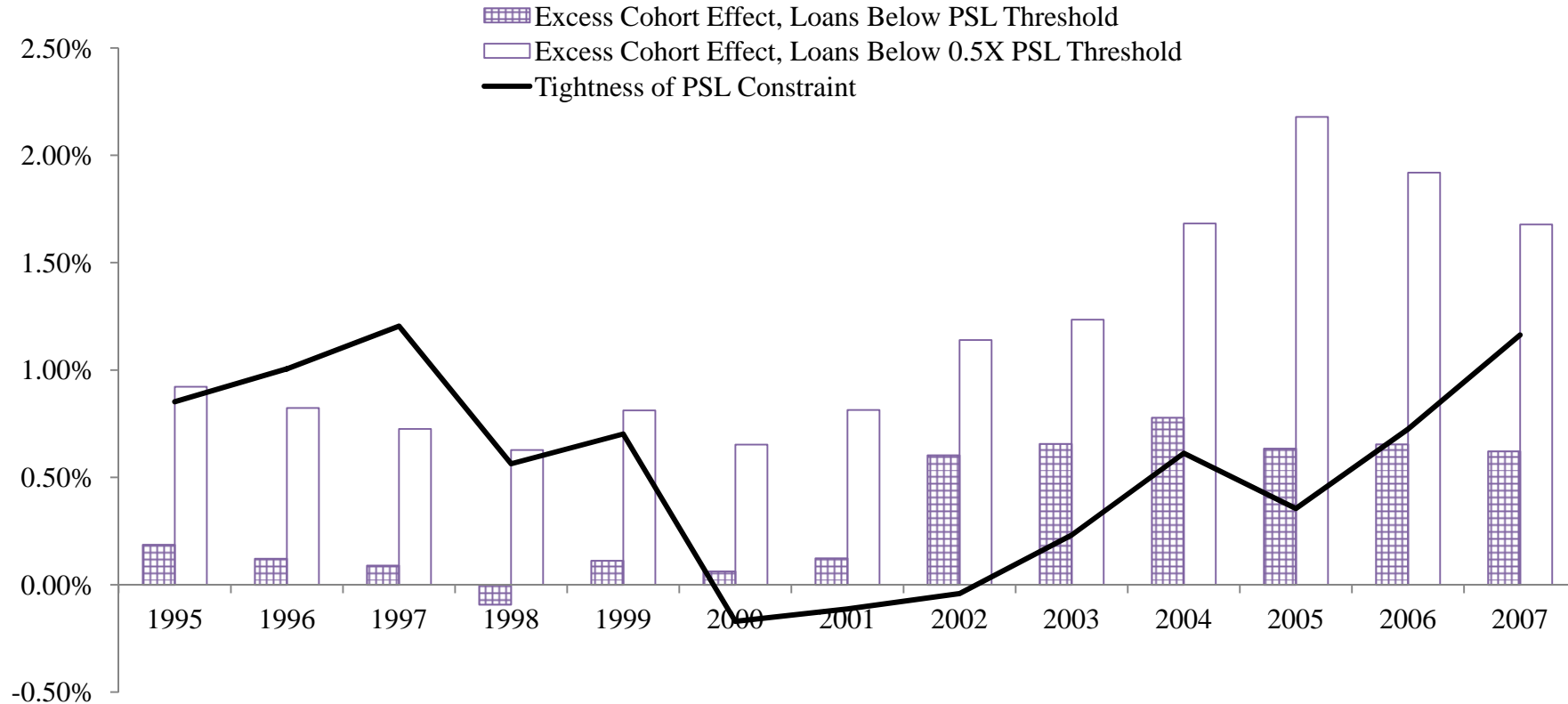
**Figure 7: De-Meaned Cohort Quantity Effects - Issuance Weighted Average of Fixed and Variable Rate Mortgages**



Notes: The cohort quantity effects plotted are the zero-mean residual of the cohort fixed effects (estimated from the delinquency model, equation 1) regressed on cohort average interest rates. The series is a weighted average of the cohort quantity effects derived separately for variable and fixed rate mortgages, where the weights for a given year are equal to the share of variable and fixed rate issuance for that cohort. The interest rate ceiling is a maximum interest rate that housing finance companies are allowed to pay to depositors. Risk weights are a multiplier used to determine the regulatory capital requirements associated with the asset; assets with higher risk weights require greater amounts of regulatory capital which reduces maximum borrower leverage.

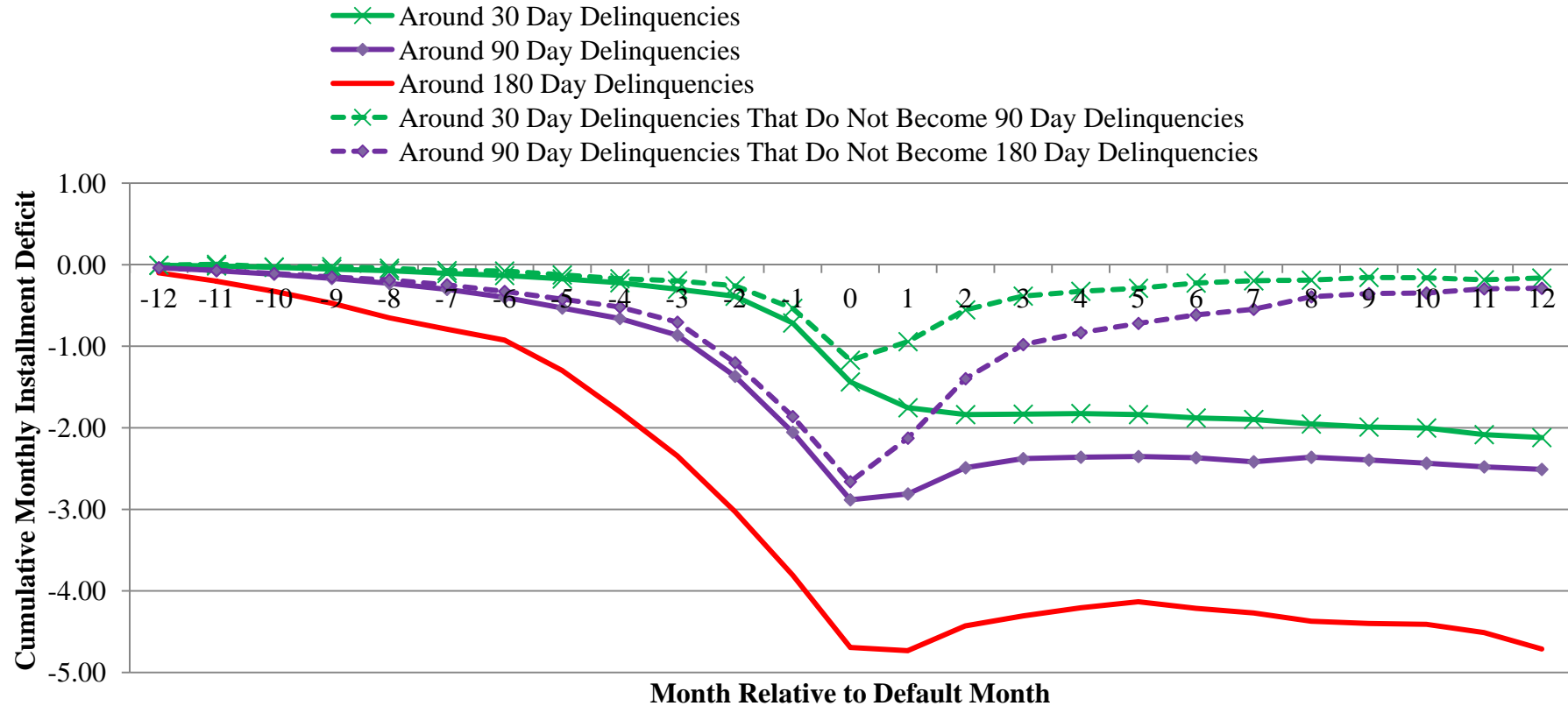


**Figure 8: Issuance Weighted Average Cohort Effects by Size in Excess of Cohort Effects for Loans Above PSL Thresholds**



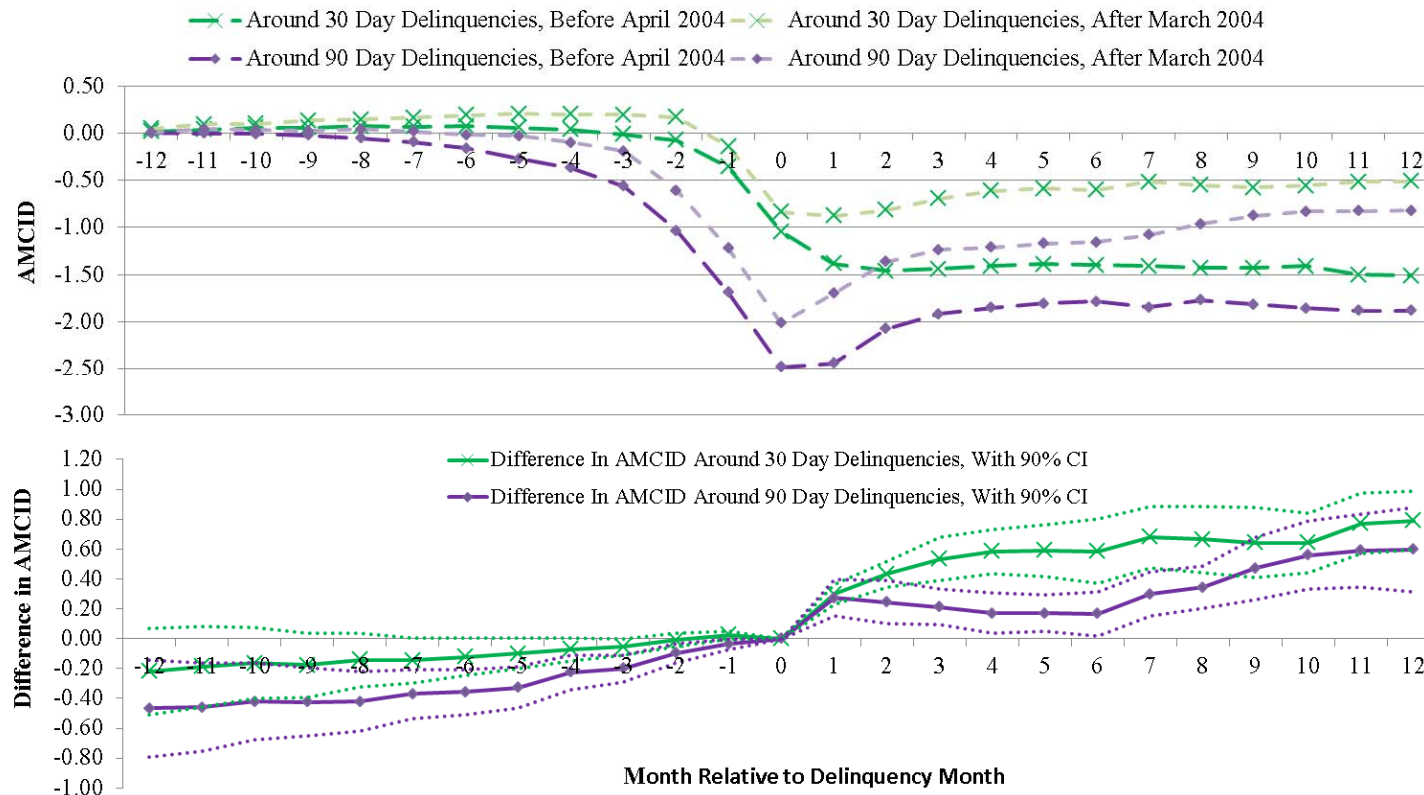
Notes: The issuance weighted average excess cohort effects are the weighted average of the fixed rate and variable rate excess cohort effects from the delinquency model using cohort X size fixed effects (equation (1) modified as specified in Table 5), where weights are the fraction of the total value of mortgage loans disbursed that are fixed or variable rate. They represent the incremental propensity to delinquency of smaller loans over those of loan above the PSL threshold at the time of loan disbursal. The series "tightness of PSL constraint" equals minus the log home-price adjusted priority sector lending threshold, as explained in the text. Priority sector lending thresholds are detailed in the Appendix on Prudential Mortgage Regulation in India.

**Figure 9: Cumulative Installment Deficits Accruing Around Delinquencies**



Notes: For each loan in the sample of 10,000 mortgage loans, the cumulative installment deficit is computed as the minimum of zero or the cumulative monthly payments minus the cumulative monthly payments due to the lender. The cumulative installment deficit for loans approaching delinquency is computed by accumulating the average change in cumulative installment deficit across all loans that are the same number of months from delinquency. Two of the series below further include only those 30 or 90 day delinquent loans which do not become 90 or 180 day delinquencies respectively.

**Figure 10: Abnormal Monthly Cumulative Installment Deficit (AMCID) Around Delinquencies**



Notes: Abnormal installment deficit is given by the estimated coefficients on time to delinquency (interacted with a post-March 2004 dummy) from a regression predicting changes in the cumulative installment deficit. The post-March 2004 dummy allows for a different pattern of abnormal installment deficits to emerge around delinquencies following the change in regulatory definition of non-performing assets. This model includes time and cohort fixed effects and is run separately for 30 and 90 day delinquencies. Top Panel: The abnormal cumulative installment deficit is the cumulative sum of the abnormal installment deficits estimated from the model. Bottom Panel: The series shown is the difference in the series plotted in the top panel accumulated backwards and forwards in time from the month of delinquency. The 90% confidence intervals shown are computed by bootstrapping years of observations separately from the groups 1996-2003 and 2004-2010.