

# How Do Regulators Influence Mortgage Risk?

## Evidence from an Emerging Market

John Y. Campbell and Tarun Ramadorai<sup>1</sup>

March 7, 2012

---

<sup>1</sup>Campbell: Department of Economics, Littauer Center, Harvard University, Cambridge MA 02138, USA, and NBER. Email [john\\_campbell@harvard.edu](mailto:john_campbell@harvard.edu). Ramadorai: Saïd Business School, Oxford-Man Institute of Quantitative Finance, University of Oxford, Park End Street, Oxford OX1 1HP, UK, and CEPR. Email [tarun.ramadorai@sbs.ox.ac.uk](mailto:tarun.ramadorai@sbs.ox.ac.uk). We gratefully acknowledge an Indian mortgage provider for providing us with the data, and many employees of the Indian mortgage provider, S. Sridhar, and R. V. Verma for useful conversations. We thank the International Growth Centre and the Sloan Foundation for financial support, and Vimal Balasubramaniam and Ben Ranish for able research assistance.

## **Abstract**

This paper uses microeconomic data from India to explore the effects of rapidly changing regulation on mortgage lending and mortgage risk. We find evidence that regulation has important effects on rates and defaults. We also find evidence suggestive of learning by the mortgage provider in a turbulent regulatory environment.

*JEL classification:* G21, R21, R31.

# 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. 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 the academic literature has reached no consensus on the degree to which regulation, rather than other factors, caused the US mortgage credit boom.

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.

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 1995 and 2010, and attempt to understand both the macroeconomic and microeconomic determinants of mortgage rate setting and delinquencies (henceforth, we use the term ‘defaults’ interchangeably with three-month payment delinquencies). Simple plots reveal a significant spike in delinquencies in the early 2000s, which remains even after we control for demographic information and loan characteristics in more sophisticated specifications. Moreover, we are unable to pinpoint any obvious macroeconomic causes of this event. However,

regulatory changes encouraged mortgage lending at that time, which we regard as unusually compelling evidence for regulatory effects on mortgage defaults, especially in light of the fact that defaults are primarily concentrated in recent cohorts of mortgage issuance. We do not merely restrict our analysis to the time series of aggregate mortgage default rates, but also provide evidence from the cross-section of defaults conditioned on various loan attributes. One interesting finding is that defaults on small loans, which are most subject to regulation, were particularly high at this time.

We also use our data to explore the question of market efficiency. An efficient mortgage market will set mortgage rates for individual borrowers in line with default risk, after adjusting for regulatory incentives that may reward lenders for making certain types of loans. We ask whether mortgage rates and default risk line up in our dataset and find that they generally do. We then look at whether the mortgage provider learned through this tumultuous regulatory period. We do provide some evidence consistent with learning over time by the mortgage provider, but changes over time in overall default rates make it hard to demonstrate this conclusively.

The organization of the paper is as follows. Section 2 sets the stage by describing the Indian macroeconomic environment over the past two decades, and summarizing the Indian system of mortgage regulation. Further details on that system are provided in an online appendix. Section 3 presents a time-series analysis of mortgage delinquencies. It estimates a hazard model of default, with both demographic variables and cohort-time effects, and shows that changing demographic characteristics of borrowers cannot 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, particularly in the late 1990s. Section 5 asks to what extent initial mortgage interest rates predict delinquencies. There is some evidence that this relationship has changed over time, which is suggestive evidence of learning by Indian mortgage lenders. Section 6 concludes.

## 2 The Macroeconomic and Regulatory Environment

### 2.1 Macroeconomic and Mortgage Finance Trends

To set the stage, we use a series of figures to illustrate the history of important macroeconomic variables over the past quarter-century in India. Figure 1 plots annual real GDP growth and CPI inflation from 1985 through 2010. Regulatory and macroeconomic reform in the early 1990s was followed by growth in the 4-7% 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.

Figure 2 shows Indian government bond yields over the same period. The 1-year yield, shown as a green line, 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, shown as a purple line, is smoother but also undergoes a large decline from the mid-1990s until the early 2000s.

Figure 3 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 4 illustrates one aspect of this change, a shift from a predominantly fixed-rate mortgage system to one that is dominated by variable-rate lending. The figure shows 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 sudden shift back towards fixed-rate mortgages in 2004 is an interesting question that we discuss later in the paper.

Figure 5 shows how Indian mortgage rates responded to market conditions, including the changes in government bond yields plotted in Figure 2. The 1-year and 10-year government bond yields are shown again in this figure as blue lines (dashed and solid, respectively). Initial interest rates on variable-rate and fixed-rate mortgages are shown as a dashed green line and a solid purple line, respectively. The two rates track one another very closely until 2002, despite declining bond yields and cyclical 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. 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.

Finally, Figure 6 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 a major focus of our study. 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.

## 2.2 The Regulatory Environment

In the remainder of this paper, we will try to relate the series plotted above, particularly those in Figures 4 and 6, to changes in the Indian regulatory environment for housing finance. Our empirical work requires a basic understanding of the regulatory structure in India.

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. Regulations can be divided into two types: those that restrict the funding of mortgage lending, and those that incentivize lending to favored borrowers. Until 2002, 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.

Lending to small borrowers is an important political goal in India. Both the RBI and NHB currently provide interest rate subventions 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. There are also special subsidy and refinancing schemes in place for very small urban loans, and rural loans made to borrowers qualifying for affirmative action. In addition, 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: 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 qualifying mortgage loans. The effect of this system is to provide a strong incentive, directly for banks, and indirectly for HFCs, to originate small mortgages that finance low-cost housing purchases.

It is not a trivial task to document the changes in Indian mortgage regulation as these have been frequent and are not summarized in any one place. The online appendix to

this paper, Campbell and Ramadorai (2012), provides further details about the regulatory system.

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

In this section we ask what factors contributed to changes in the mortgage delinquency rate over time, with special attention to the regulatory changes described in the previous section. We begin by controlling for changes over time in demographic characteristics of borrowers and measurable characteristics of loans. We estimate a hazard model that decomposes the time-series variation in default rates into cohort-time variation and demographic/loan characteristic variation. The equation we estimate can be written as

$$\delta_{i,c,b,t} = FE(Branch, Cohort \times Time) + f(Dem., LoanChars) + \gamma r_{i,c,b} + e_{i,c,b,t}^{\delta}, \quad (1)$$

where  $\delta_{i,c,b,t}$  is an indicator for 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 and each cohort-time pair. It also includes demographic and loan characteristics and the initial interest rate on the mortgage,  $r_{i,c,b}$ . The model is estimated separately for fixed-rate and variable-rate loans.

The demographic variables in the regression include gender, marital status, the number of dependents of the borrowed, and dummies for age (up to age 35, 36-45, and 46 and above), education (high-school (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, dummies for loan size and 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 branch-level house-price appreciation up to time  $t$  from the time of the disbursement of the loan. Table 1 shows the estimated coefficients from the model.

Figures 7 and 8 summarize the implications of this regression for time-variation in delinquency rates on variable-rate and fixed-rate mortgages, respectively. In each year from 1996 through 2010, the bars report the overall delinquency rate (delinquent mortgages in each year as a fraction of all outstanding mortgages in that year, regardless of their cohort), and the components attributed to demographics and loan characteristics, on the one hand, and cohort-time dummies, on the other hand. The spike in the delinquency rate in 2002 and 2003 is attributed entirely to cohort-time dummies; in both figures the demographic and loan characteristic effects trend downwards over time, indicating that loans are being made to safer borrowers and with safer characteristics over time. The figures also show that real GDP growth (whose scale is on the right vertical axis) does not vary in a way that would naturally explain delinquencies in 2002 and 2003, although rapid GDP growth in the mid-2000s may have something to do with the low delinquency rates at that time. We have earlier shown house prices in Figure 3, and house appreciation at the branch level is included in the the set of loan characteristics in these specifications. Clearly, they are no more promising as an explanation for changing delinquency rates.

Figures 9 and 10 are designed in a similar manner, but show only the time-cohort bars from the previous figures. These bars are broken into their constituent cohorts, a decomposition that reveals that the delinquency spike in 2002 and 2003 was particularly pronounced in relatively new mortgages issued in the current year or the immediately preceding year.

Superimposed on these bar charts are two lines 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. The interest-rate ceiling is multiplied by three 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. The period with no interest-rate ceiling coincides 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 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.

The dashed line summarizes changing risk weights for housing loans, constructed by averaging the risk weights that apply to banks and to HFCs, and scaled as shown on the right vertical axis. The decline in risk weights in 2002 and 2003 coincides precisely with the higher delinquency rates in those years, and a subsequent hump in risk weights in 2005 and 2006 coincides with unusually low delinquency rates. While one must always be cautious about the interpretation of any pure time-series correlation, Figures 9 and 10 are strongly suggestive that changes in regulation drove the delinquency patterns in our data.

## 4 Regulation and Delinquencies: Cross-Sectional Evidence

Risk weights and interest rate ceilings are not the only regulatory instruments through which the Reserve Bank of India affects mortgage lending. 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 these regulatory instruments are important, they might induce mortgage lenders to make riskier loans to small borrowers. As a simple way to measure the relative riskiness of small loans, Figure 11 plots the difference between the equal-weighted delinquency rate and a value-weighted delinquency rate, for fixed-rate mortgages (solid line) and variable-rate mortgages (dashed line). The figure shows that delinquencies were concentrated in small loans in the mid-2000s for fixed-rate mortgages, and in the later 2000s for variable-rate mortgages.

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). In order to assess this explanation, we compare delinquency rates and initial mortgage rates for different sizes of loans, and use information on the PSL

qualifying size thresholds over time to understand the effects of being in the favored category. We create a set of loan size buckets and regress both lifetime delinquency rates and initial mortgage rates against loan size dummies for each bucket (the plots show loan-size dummies from regressions that include an expanded set of controls, in which lifetime delinquency rates and initial mortgage rates are regressed on demographics, cohort- and branch- fixed-effects, and loan characteristics, in addition to the loan-size dummies). The size buckets range from under \$1,000 to over \$100,000.

We illustrate the results using a series of figures. In each figure, the horizontal axis shows the initial mortgage rate, relative to the rate on the smallest loan size bucket that does not qualify for PSL status. The vertical axis shows the default propensity, again relative to the smallest non-qualifying loan size bucket. That bucket therefore plots at the origin on the graph. Other size buckets lie to the northwest if they are riskier and have lower initial interest rates and to the southeast if they are safer and have higher initial rates. In an efficient mortgage market without regulatory distortions, one would expect the various size buckets to lie on a straight line with a positive slope passing through the origin.

We indicate the position of each size bucket using a bubble whose area corresponds to the value of all loans in this size bucket relative to total mortgage lending. To indicate which size buckets are small enough for PSL-qualification, we shade the bubbles black if the loans qualify over the whole period and grey if they qualify for part of the period. White bubbles are larger loans that receive no regulatory subsidy. If regulatory distortions are important in the Indian mortgage market, we should see black and grey bubbles shifted to the northwest, with relatively high default risk relative to their initial interest rates.

Figures 12, 13, and 14 show results for variable-rate mortgages originated in 1995–99, 2000–04, and 2005–10, respectively. Figures 15, 16, and 17 repeat the exercise for fixed-rate loans. For both types of mortgages, we see strong evidence of regulatory distortion during the late 1990s. Grey and black points all lie in the northwest quadrant of Figures 12 and 15, while white points are in the northeast quadrant of Figure 15, and either on the horizontal axis or in the northeast quadrant of Figure 12. These distortions are important as the size of the black bubbles indicates that subsidized loans are a large part of the mortgage book.

These patterns change dramatically in the 2000s. Variable-rate loans appear quite efficiently priced in this period (Figure 13). For fixed-rate loans, we continue to see some distortions in the 2000–04 period (Figure 16) but only among a subset of PSL-qualifying loans; and the only bubble in the northwest quadrant is now a tiny fraction of the mortgage book.

In the 2005–10 period, for both fixed and variable-rate mortgages the relative pricing of PSL-qualifying loans appears quite efficient, although all these loans have a slightly higher default rate than their initial interest rates would justify. In other words, all black points are shifted to the northwest of white points, but the black points all lie on a positively sloped line. To interpret these results, one should keep in mind three points. First, fixed-rate results for this period should be treated with caution, as fixed-rate mortgages have a small market share in the second half of the 2000s. Second, results for this period may be distorted by the fact that recent loans may not yet have experienced delinquencies by the end of the sample period. Finally, PSL-qualifying loans are a much smaller fraction of the mortgage book in the late 2000s.

In conclusion, we find evidence that implicit subsidies to small loans have reduced the interest rates on these loans relative to larger unsubsidized loans, after controlling for differences in default risk. This effect diminishes over time, and is most pronounced in the late 1990s. Even in the late 2000s, however, there is some evidence of a remaining effect although unsubsidized mortgage lending is relatively more important in this period.

## 5 Learning by the Mortgage Provider

Through this tumultuous period, does the mortgage provider learn about the determinants of default? One way to assess this is to analyze the relationship between interest rates at mortgage origination, and subsequent default experience. We can measure changes in this relationship over mortgage origination dates, that is over cohorts.

Within each cohort, we can measure the cross-sectional correlation between the initial interest rate on each mortgage and a lifetime indicator of default. Alternatively, we can

calculate the cross-sectional correlation between the predicted interest rate from a regression on demographic and loan characteristics, and the predicted default indicator from a similar regression. The first correlation tells us the extent to which rates are set in line with rational forecasts of default, given all the information that the mortgage provider has. The second correlation tells us whether the mortgage provider is using measurable loan and borrower characteristics “correctly”, that is, to set rates in relation to default prospects for loans and borrowers with those characteristics. If these correlations rise over time, this may indicate that the mortgage lender is learning about default risk.

Since the second approach uses regressions, one must decide over what sample period to estimate the regression. One possibility is to use a rolling three-year window for estimation of coefficients, and then apply the estimated coefficients to annual realizations of the explanatory variables. A second possibility is to use a pooled specification, estimating the coefficients once over the entire sample period.

The regression we estimate for initial mortgage rates can be written as

$$r_{i,c,b} = FE(\textit{Branch}, \textit{Cohort}) + f(\textit{Dem.}, \textit{LoanChars}) + u_{i,c,b}^r. \quad (2)$$

The regression for the lifetime default indicator is:

$$\delta_{i,c,b} = FE(\textit{Branch}, \textit{Cohort}) + g(\textit{Dem.}, \textit{LoanChars}) + \beta r_{i,c,b} + e_{i,c,b}^\delta. \quad (3)$$

The coefficient  $\beta$  on the initial interest rate is statistically significant and positive, but has little effect on the other coefficients, so the interest rate can be excluded from this regression without changing the results, as we do in the remainder of this analysis.

As a first step, in Figures 18 and 19 we plot the cross-sectional standard deviations of mortgage rates for variable-rate and fixed-rate mortgages. We show three lines, corresponding to actual mortgage rates (solid), the fitted values from rolling regressions on demographic and loan characteristics (dot-dashed), and the fitted values from a pooled regression (dashed). Figure 18 shows a large spike in the cross-sectional dispersion of variable mortgage rates, almost exclusively in actual 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. Figure 19 shows that from 1996 through 2005 there is a downtrend in the cross-sectional dispersion of fixed mortgage rates, particularly in actual rates which implies that unexplained dispersion is decreasing over time.

Figures 20 and 21 plot the cross-sectional correlations between initial interest rates and subsequent default experience. Once again there are three lines, with the same interpretation as in the previous pair of figures. Figure 21 shows a large spike in the cross-sectional correlation for fixed-rate mortgages during the period of high delinquencies discussed earlier. This spike shows up whether we look at actual mortgage rates and defaults, or fitted values of mortgage rates and defaults regressed on demographic and loan characteristics. Figure 20 shows a similar increase for variable-rate mortgages, which is most pronounced when we run rolling regressions to predict both interest rates and defaults from demographic and loan characteristics. These figures suggest that the mortgage lender was learning from the greater availability of default data during the early 2000s and was adapting its rate-setting policy accordingly.

A final question we can answer is which demographic and loan characteristics contribute most to this change in lending behavior. Since covariances are linear, we shift from correlations to covariances and plot the rolling covariances of components of the fitted values from our rolling regressions. The components we look at include borrower attributes (demographic variables), loan cost and income ratios, dummies for loan maturity, dummies for small and large loans, other loan attributes, and branch dummies. Figure 22 shows the results for variable-rate mortgages, and Figure 23 for fixed-rate mortgages. For fixed-rate mortgages, learning seems to be most important with respect to loan maturity (term) dummies. For variable-rate mortgages, it seems to be most important with respect to loan size.

These results are related to our earlier finding that the relation between loan size, default rates, and initial mortgage rates becomes less distorted in the early 2000s than it had been in the late 1990s. In other words, the diminishing effect of PSL norms in the early 2000s may be driving the increase in the size effect in Figure 22. The decline in that effect at

the end of the sample is likely related to the decline in the delinquency rate rather than any reversal of the structural changes that took place earlier in the decade.

## 6 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 contributed to a surge in delinquencies during the early 2000s, but that mortgage lenders learned from the experience to set mortgage rates in closer relation to default risk. Our paper contributes to the growing body of literature on the impacts of regulators and regulatory norms on risks in financial markets.

## References

- Campbell, John Y., 2012, “Mortgage Market Design”, unpublished paper, Harvard University.
- Campbell, John Y. and Tarun Ramadorai, 2012, “Prudential Regulation of Housing Finance in India 1995-2011”, available at <http://kuznets.fas.harvard.edu/~campbell/papers.html>.
- Campbell, Tim S. and J. Kimball Dietrich, 1983, “The Determinants of Default on Insured Conventional Residential Mortgage Loans”, *Journal of Finance* 38, 1569–1581.
- Duca, John V. and Stuart S. Rosenthal, 1994, “Do Mortgage Rates Vary Based on Household Default Characteristics? Evidence Based on Rate Sorting and Credit Rationing”, *Journal of Real Estate Finance and Economics* 8, 99–113.
- Hunt, Stefan, 2010, “Informed Traders and Convergence to Market Efficiency: Evidence from a New Commodity Futures Exchange”, unpublished paper, Harvard University.
- International Monetary Fund, 2011, “Housing Finance and Financial Stability – Back to Basics?”, Chapter 3 in *Global Financial Stability Report, April 2011: Durable Financial Stability – Getting There from Here*, International Monetary Fund, Washington, DC.
- Keys, Benjamin, Tanmoy Mukherjee, Amit Seru, and Vikrant Vig, 2010, “Did Securitization Lead to Lax Screening? Evidence from Subprime Loans”, *Quarterly Journal of Economics* 125, 307–362.
- Mian, Atif and Amir Sufi, 2009, “The Consequences of Mortgage Credit Expansion: Evidence from the U.S. Mortgage Default Crisis”, *Quarterly Journal of Economics* 124, 1449–1496.
- Tiwari, Piyush and Pradeep Debata, 2008, “Mortgage Market in India”, Chapter 2 in Danny Ben-Shahar, Charles Ka Yui Leung, and Seow Eng Ong eds. *Mortgage Markets Worldwide*, Blackwell.

Verma, R.V., 2012, “Evolution of the Indian Housing Finance System and Housing Market”, Chapter 14 in Ashok Bardhan, Robert H. Edelstein, and Cynthia A. Kroll eds. *Global Housing Markets: Crises, Policies, and Institutions*, John Wiley.

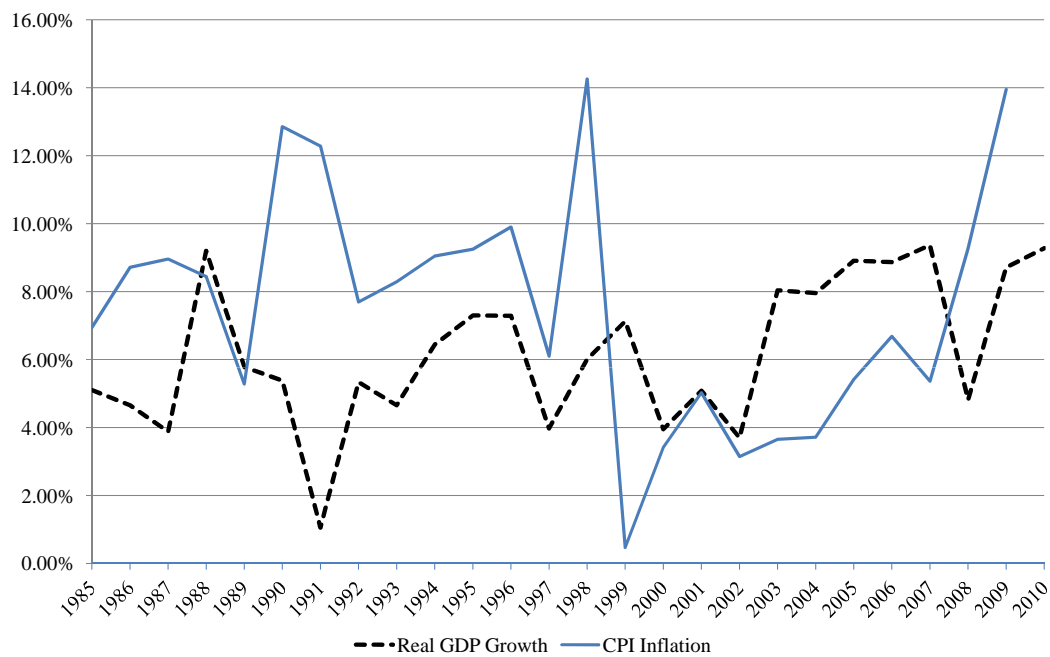


Figure 1: Indian real GDP growth and CPI inflation.

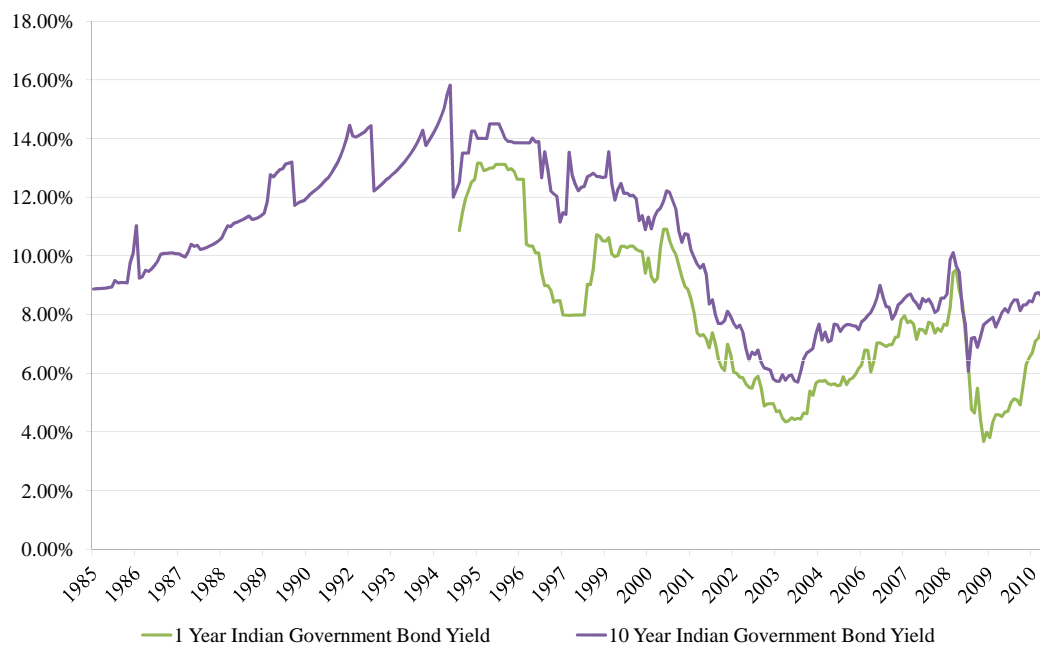


Figure 2: Indian one- and ten-year government bond yields.

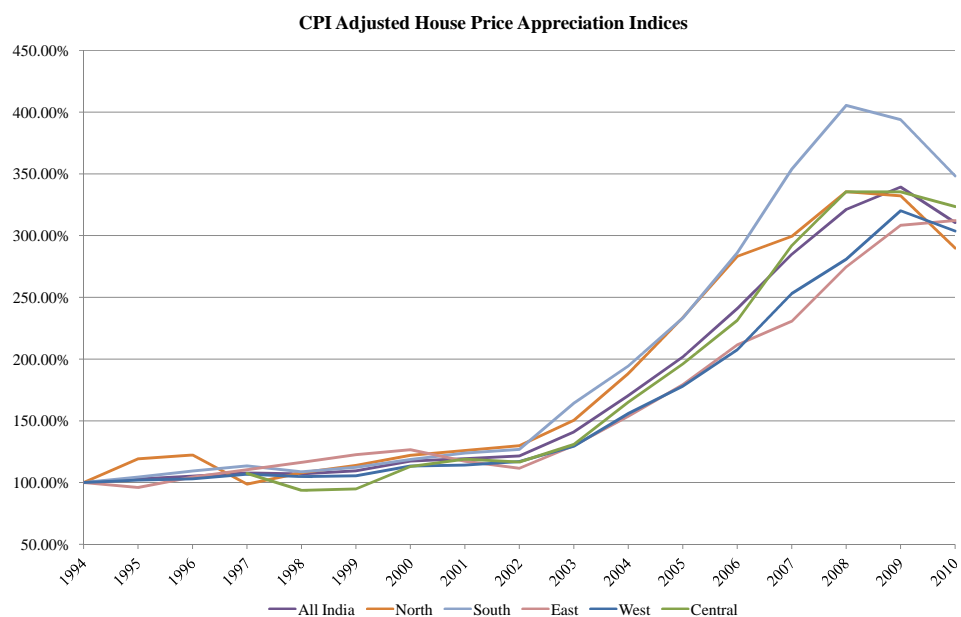


Figure 3: CPI adjusted house price appreciation indices for Indian regions.

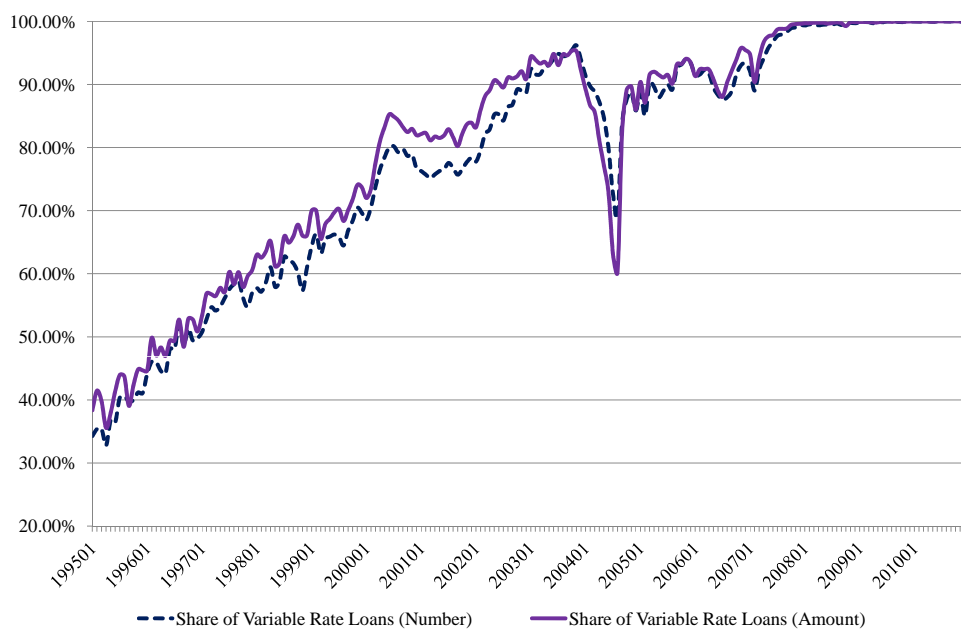


Figure 4: Share of variable rate loans in total mortgage issuance.

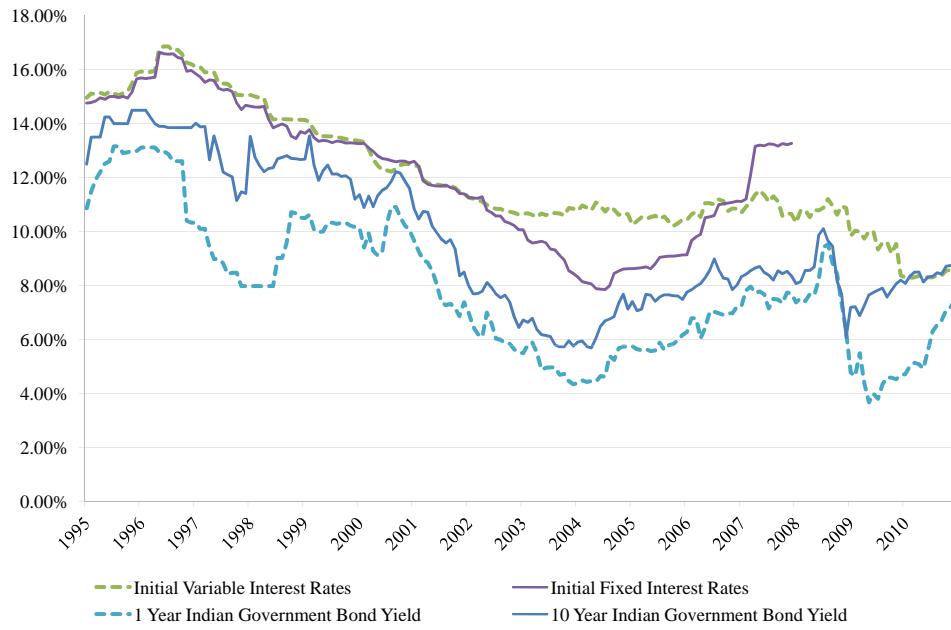


Figure 5: Initial fixed and variable rates for mortgages, average across all loans issued in each cohort.

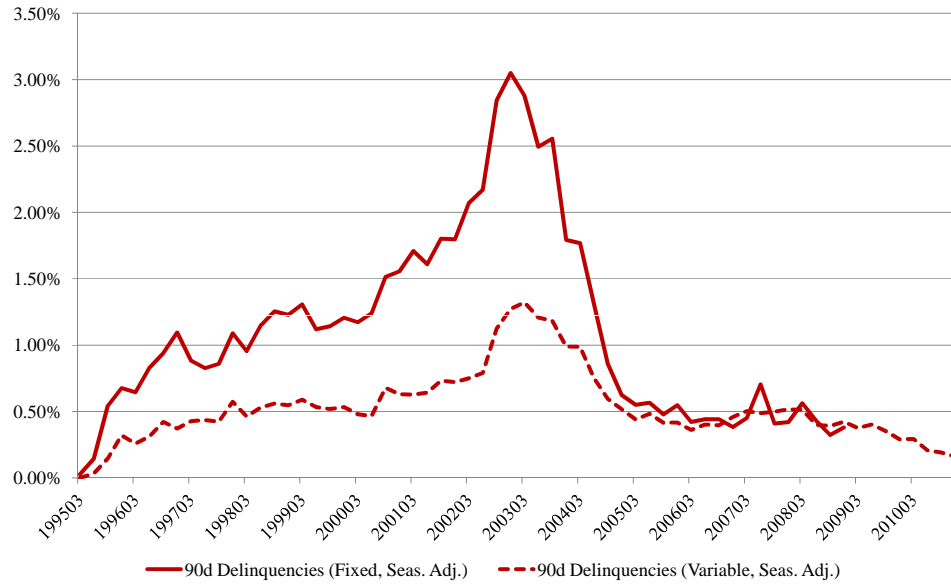


Figure 6: Default Rate, 90 days past due, seasonally adjusted.

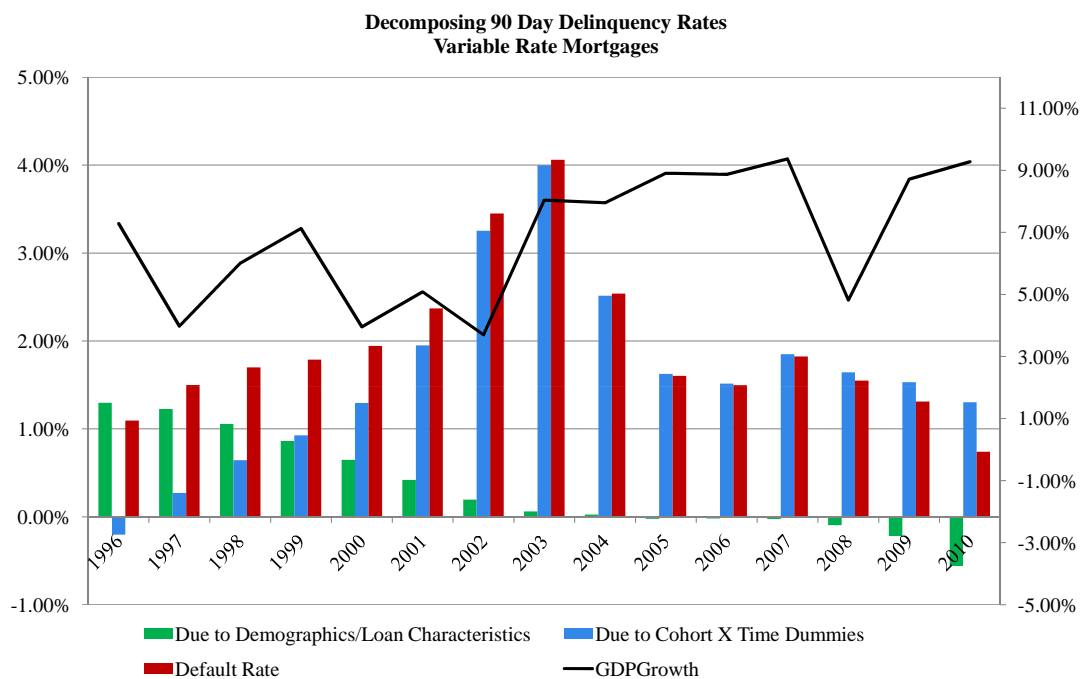


Figure 7: Decomposing default-rate variation: Variable-rate loans

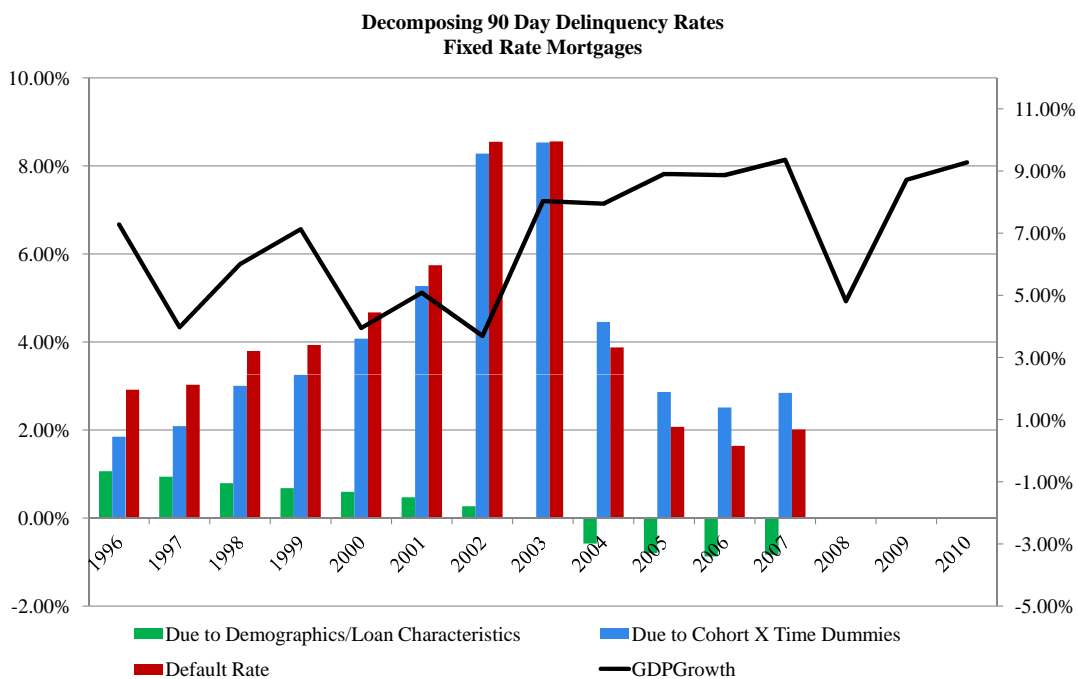


Figure 8: Decomposing default-rate variation: Fixed-rate loans

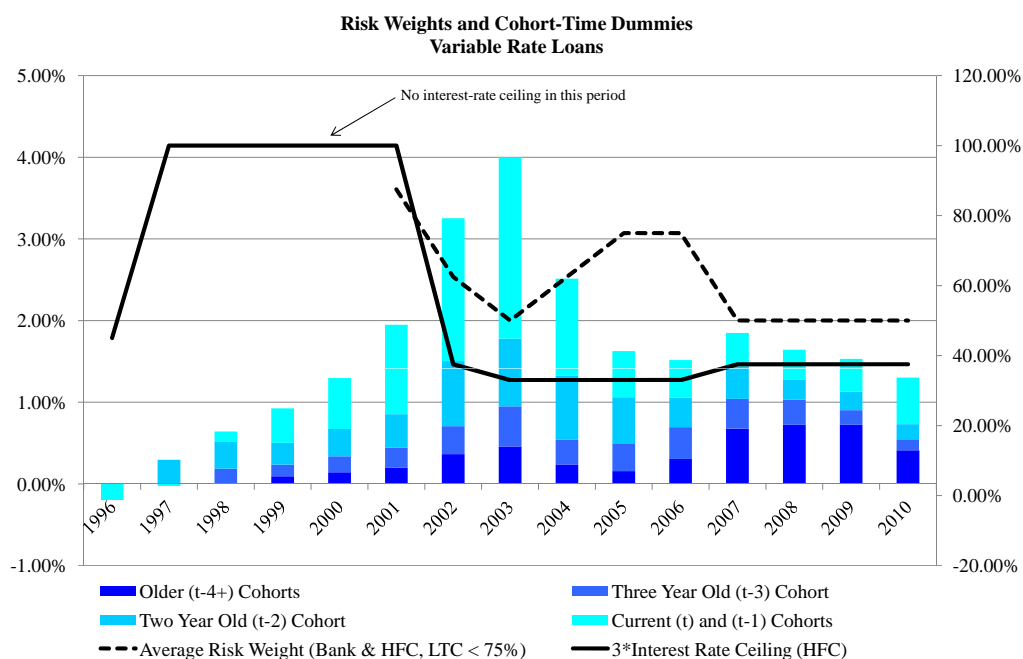


Figure 9: Risk weights and cohort-time fixed effects (cohort-time fixed effects grouped by cohort), variable-rate loans.

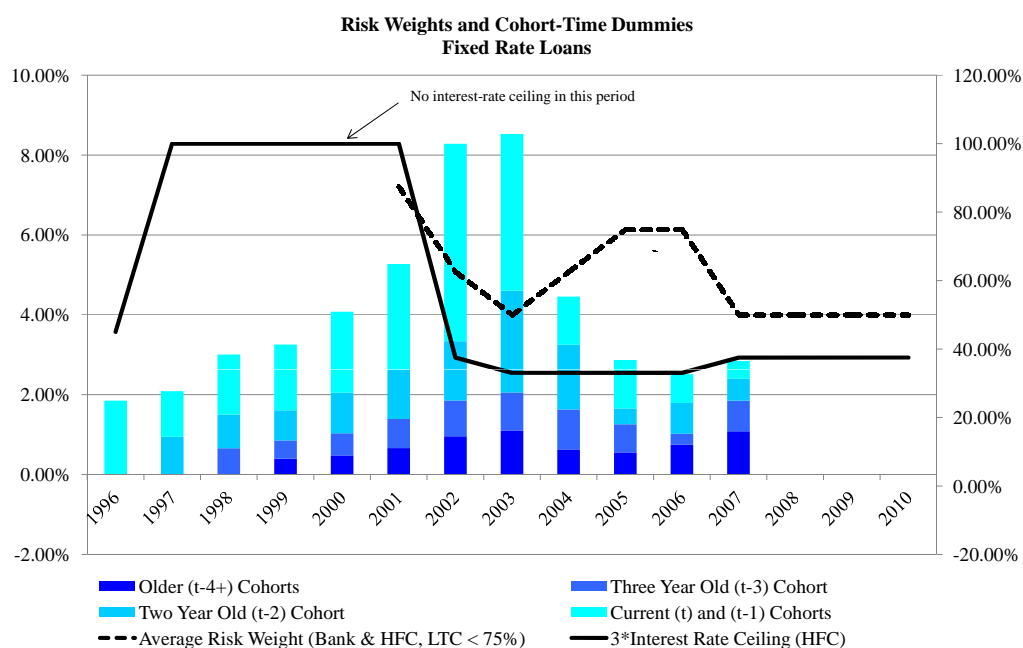


Figure 10: Risk weights and cohort-time fixed effects (cohort-time fixed effects grouped by cohort), fixed-rate loans.

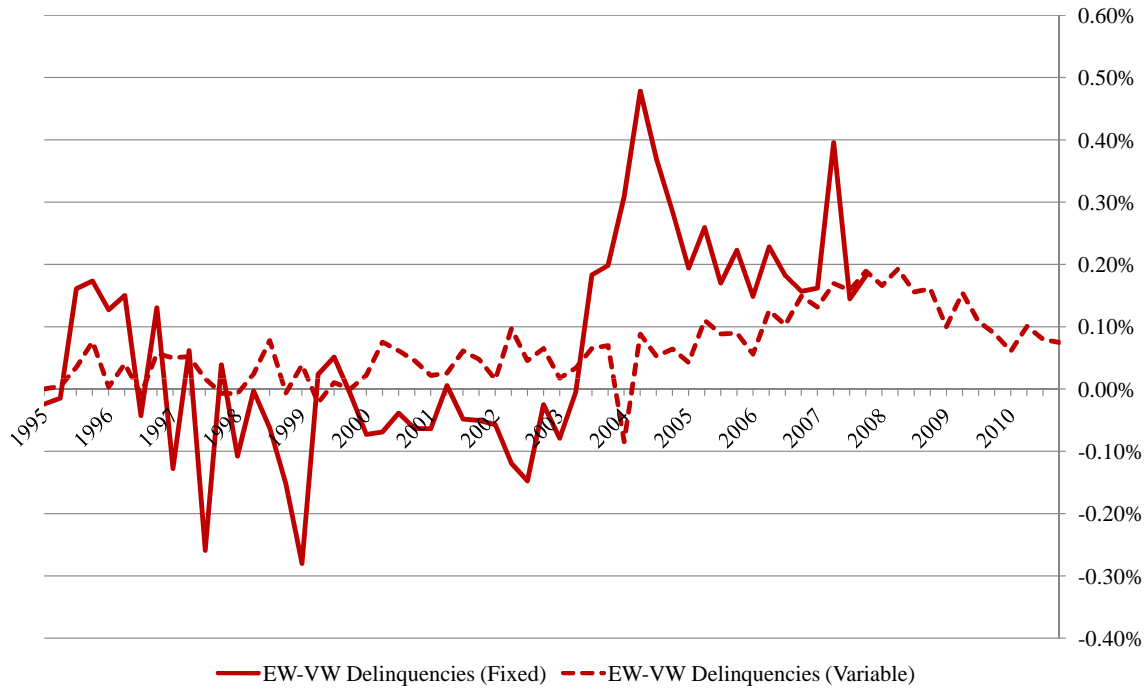


Figure 11: Default Rate, 90 days past due Equal weighted default rate - Asset-weighted default rate

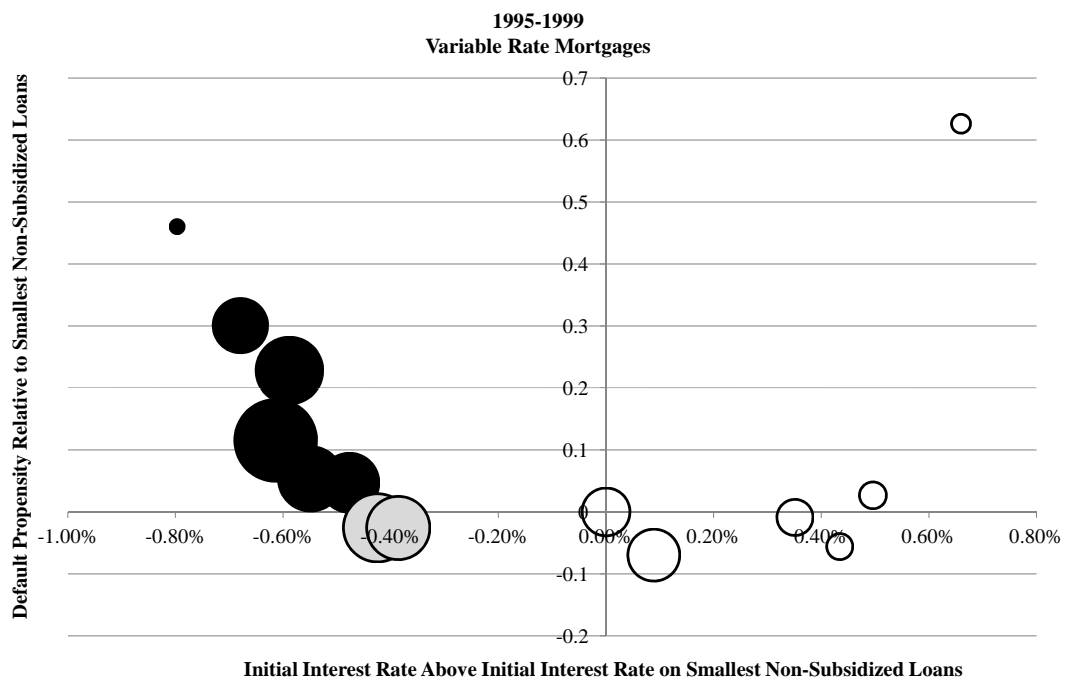


Figure 12: Cross-sectional impacts of regulation, variable-rate loans, 1995-1999.

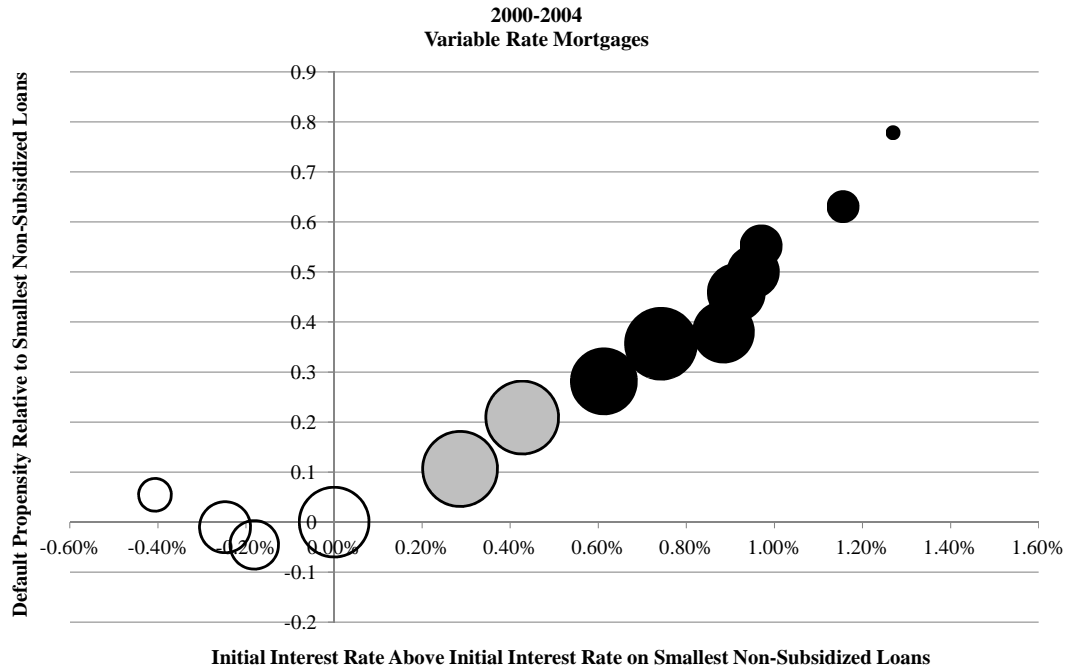


Figure 13: Cross-sectional impacts of regulation, variable-rate loans, 2000-2004.

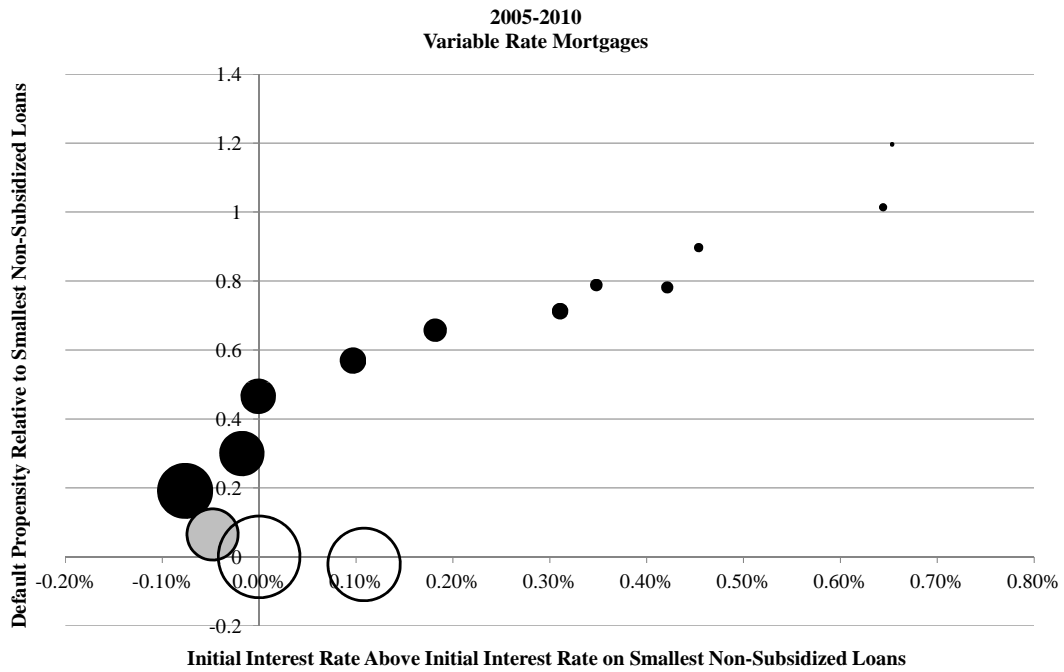


Figure 14: Cross-sectional impacts of regulation, variable-rate loans, 2005-2010.

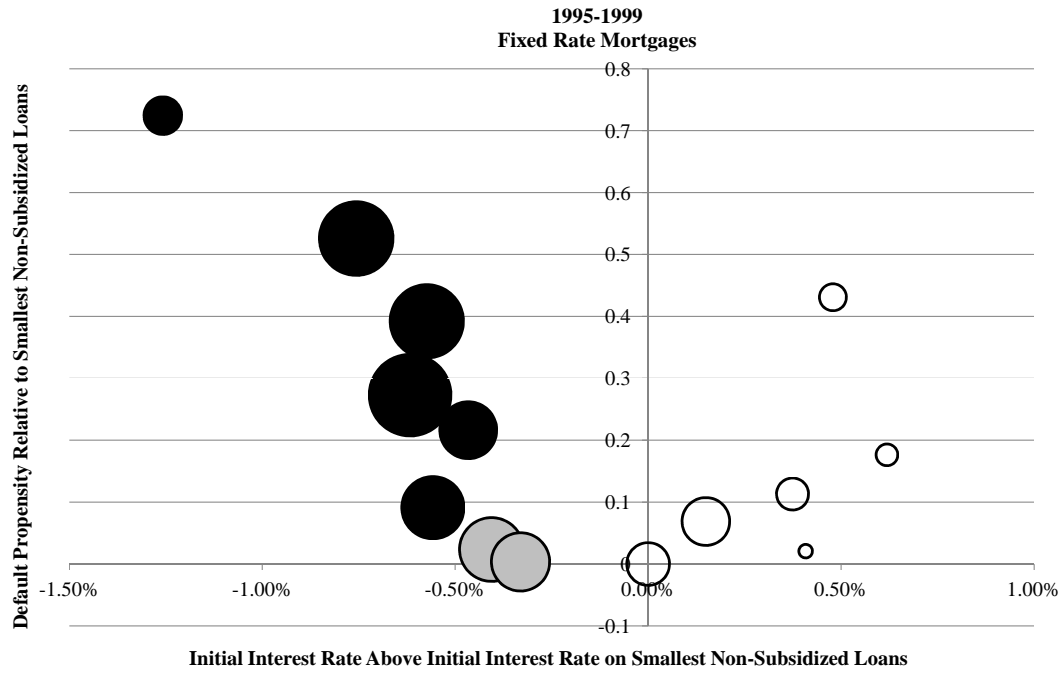


Figure 15: Cross-sectional impacts of regulation, fixed-rate loans, 1995-1999.

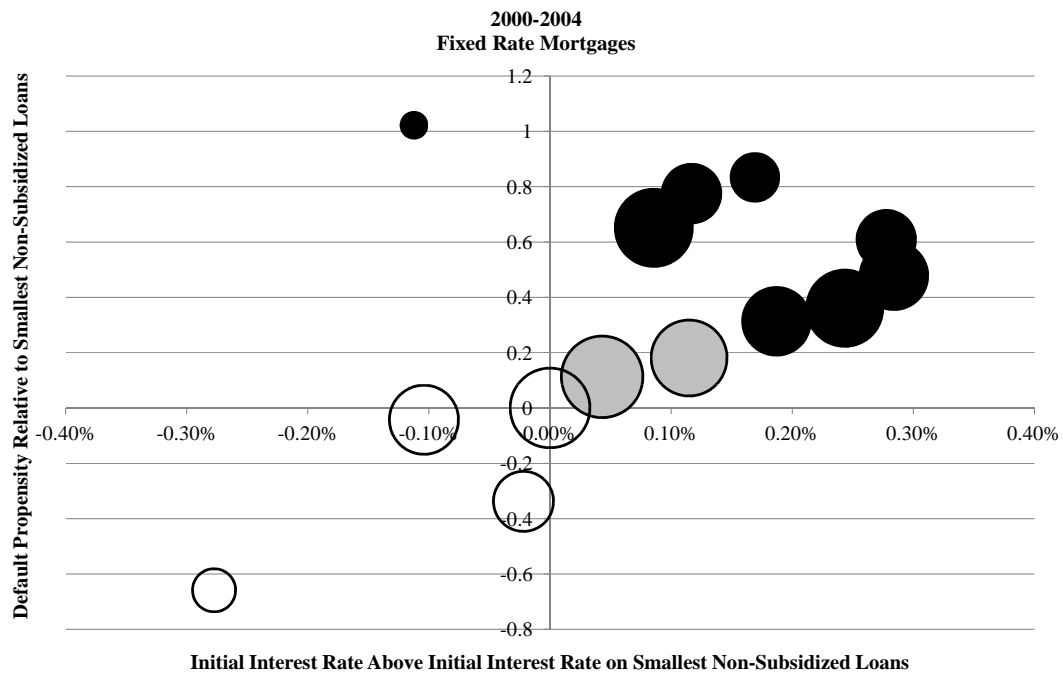


Figure 16: Cross-sectional impacts of regulation, fixed-rate loans, 2000-2004.

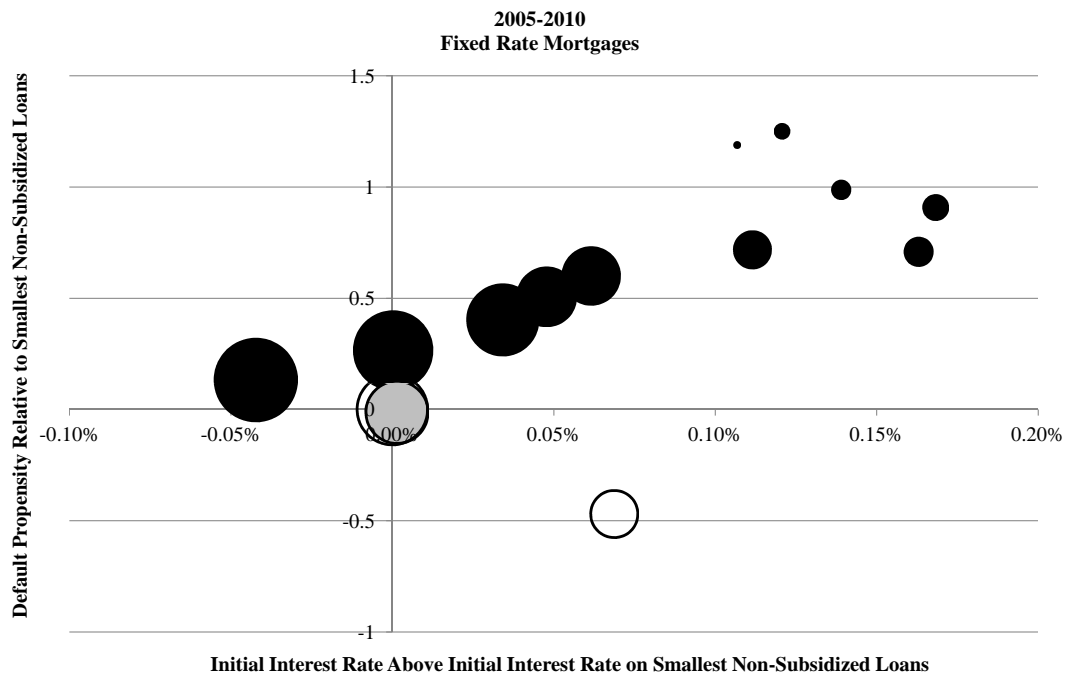


Figure 17: Cross-sectional impacts of regulation, fixed-rate loans, 2005-2010.

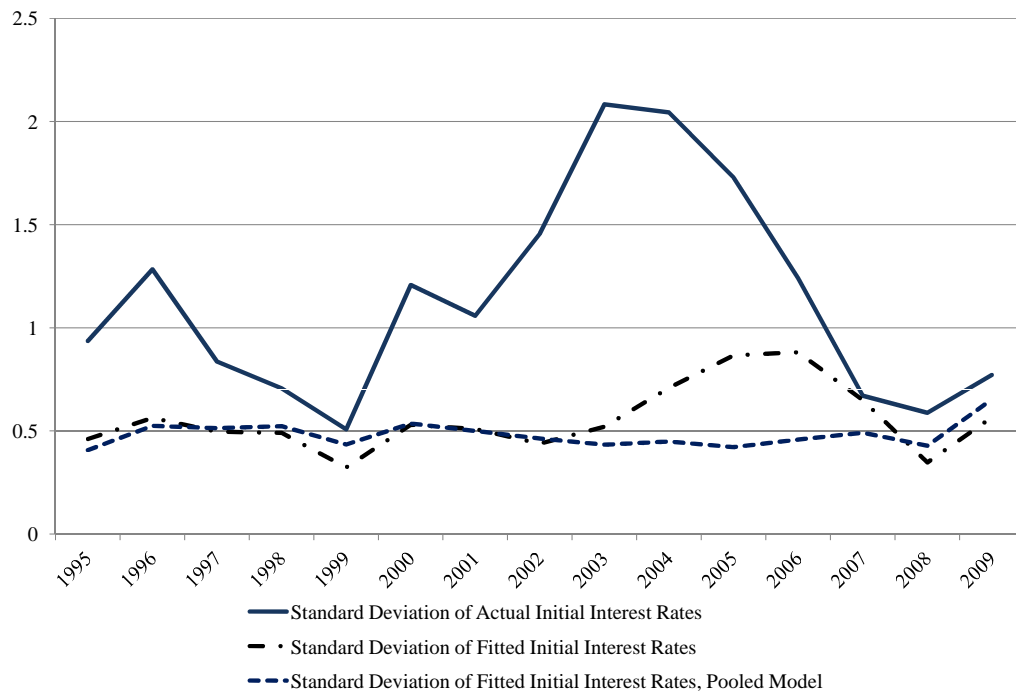


Figure 18: Cross-sectional standard deviations of mortgage rates, variable-rate mortgages.

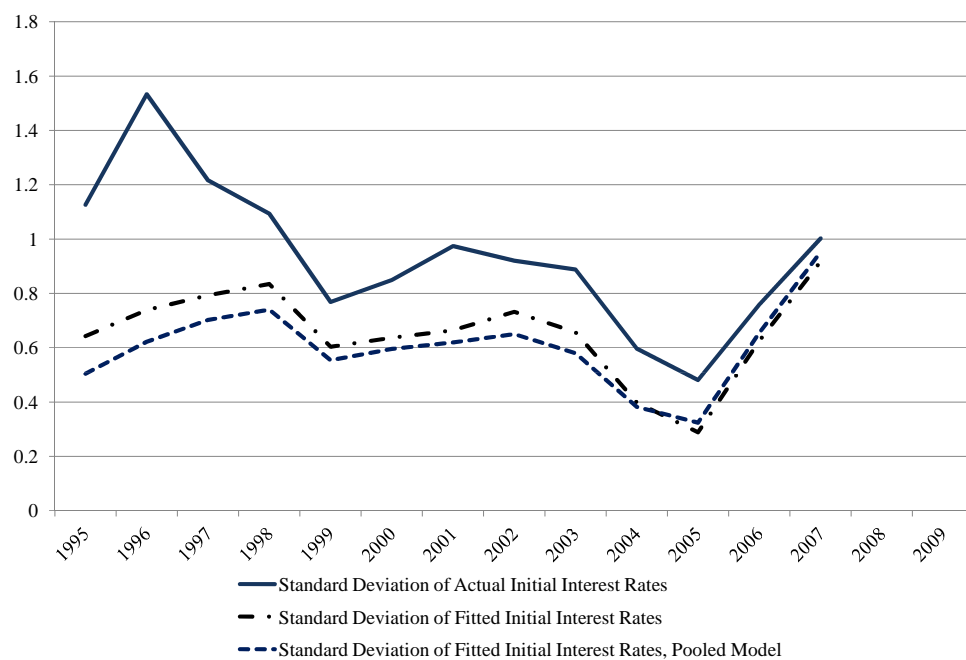


Figure 19: Cross-sectional standard deviations of mortgage rates, fixed-rate mortgages.

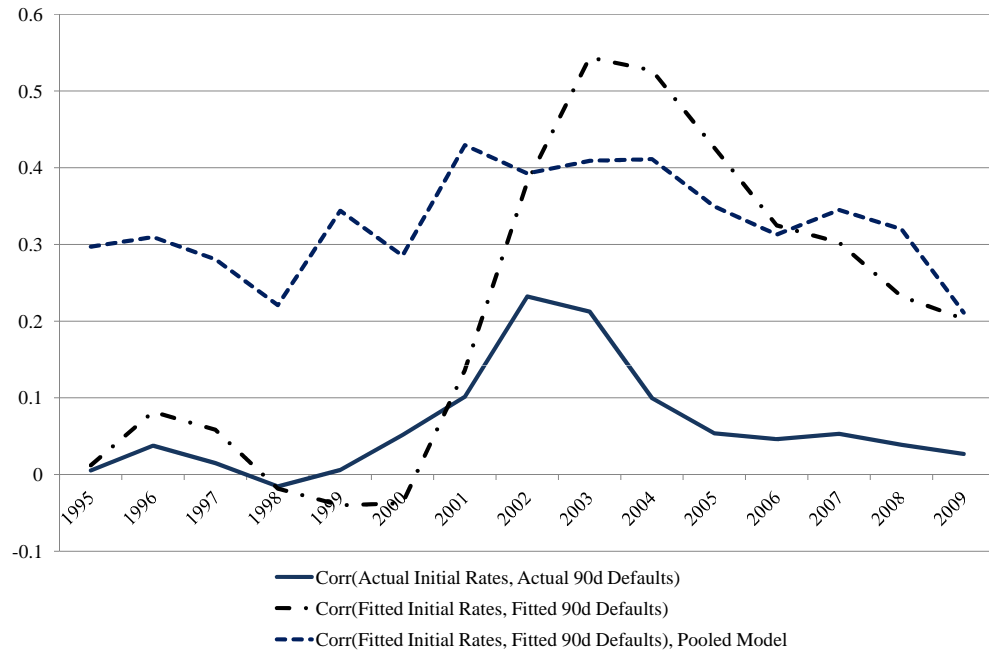


Figure 20: Cross-sectional correlations between initial interest rates and subsequent default experience, variable-rate loans.

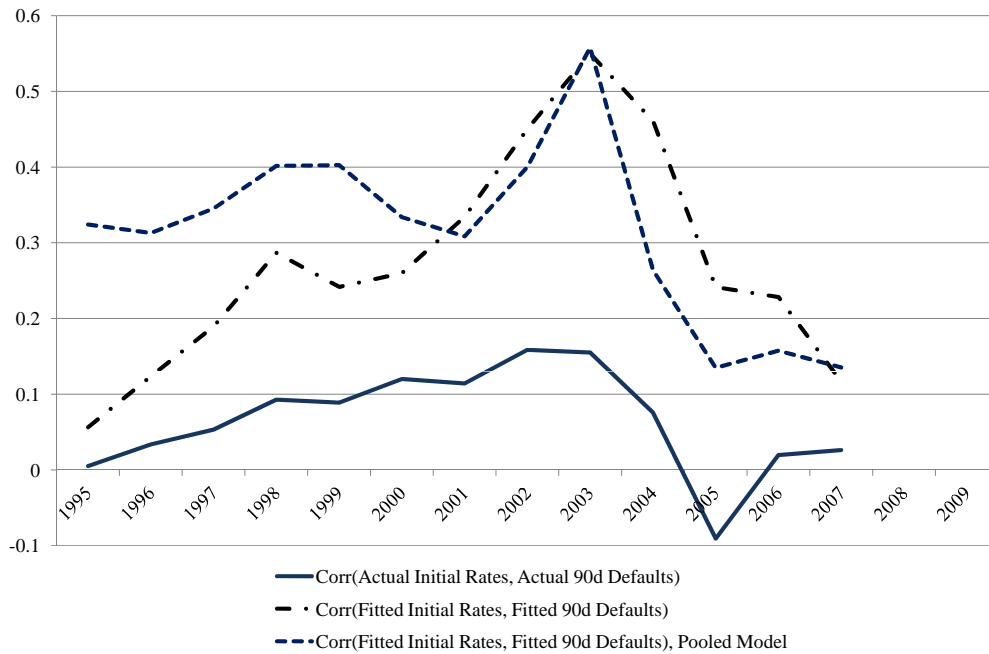


Figure 21: Cross-sectional correlations between initial interest rates and subsequent default experience, fixed-rate loans.

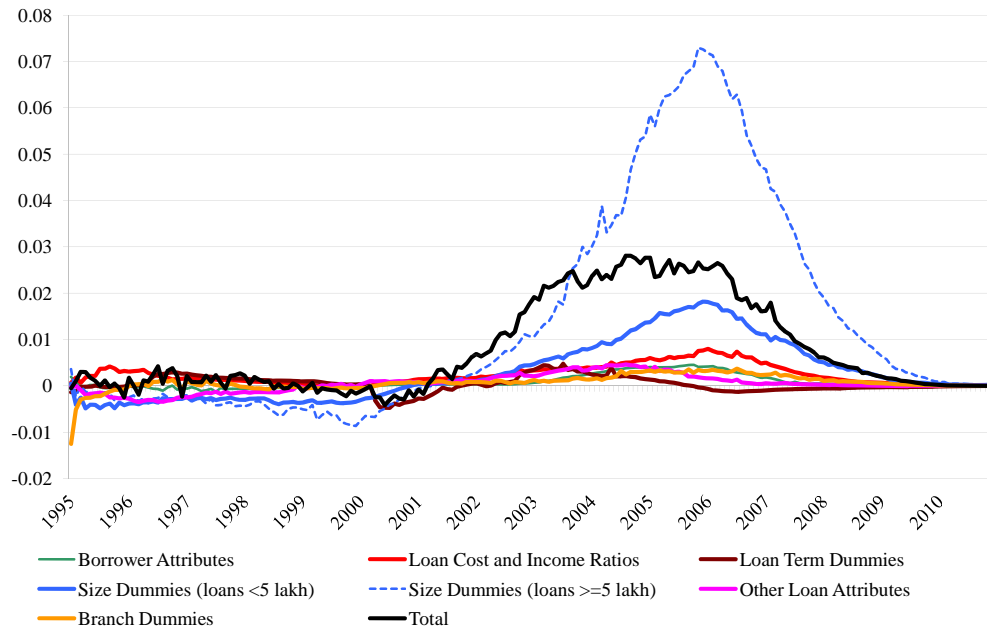


Figure 22: Covariances of components of the fitted values from our rolling regressions, variable-rate mortgages.

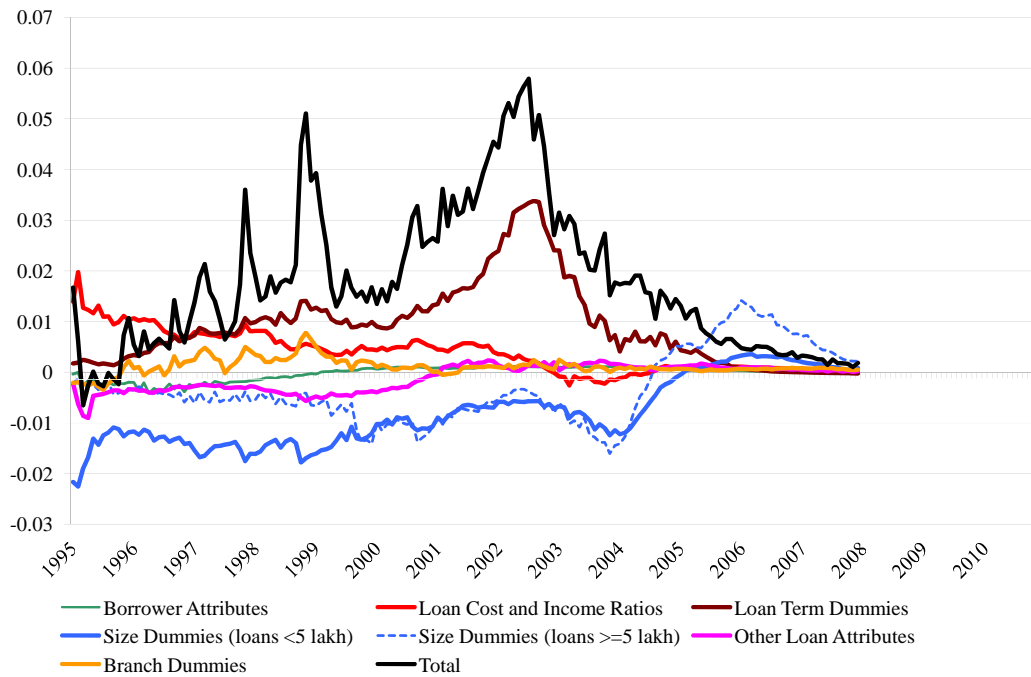


Figure 23: Covariances of components of the fitted values from our rolling regressions, fixed-rate mortgages.

**Table 1: Default Hazard-Rate Model**

This table presents coefficient estimates and t-statistics (clustered by calendar year) from estimates of equation (1) in the paper.

	Fixed-Rate Loans		Variable-Rate Loans	
	Coefficient	T-stat	Coefficient	T-stat
Local Home Price Appreciation	0.0035	1.07	<b>0.0036</b>	2.07
Initial Interest Rate (in Percent)	<b>0.0044</b>	4.13	<b>0.0036</b>	4.37
Repeat Borrower	<b>0.0073</b>	3.55	<b>0.0029</b>	2.18
Male Borrower	<b>0.0051</b>	5.69	<b>0.0018</b>	4.77
Married Borrower	0.0013	1.34	0.0003	0.84
Borrower age 36-45	0.0008	1.24	<b>0.0005</b>	2.87
Age 46 and up	<b>0.0020</b>	2.55	<b>0.0018</b>	2.97
Number of Dependents	<b>0.0019</b>	3.23	-0.0002	-1.50
Loan to Cost Ratio	<b>0.0561</b>	5.19	<b>0.0221</b>	9.23
Log Loan to Income Ratio	<b>0.0133</b>	5.14	<b>0.0056</b>	12.42
Loan amount 0.5 to 1 lakh	<b>-0.0099</b>	-3.42	<b>-0.0059</b>	-6.96
Loan amount 1 to 1.5 lakh	<b>-0.0131</b>	-4.13	<b>-0.0080</b>	-8.89
Loan amount 1.5 to 2 lakh	<b>-0.0196</b>	-4.09	<b>-0.0110</b>	-14.21
Loan amount 2 to 2.5 lakh	<b>-0.0213</b>	-5.28	<b>-0.0093</b>	-12.83
Loan amount 2.5 to 3 lakh	<b>-0.0291</b>	-5.68	<b>-0.0126</b>	-14.97
Loan amount 3 to 4 lakh	<b>-0.0330</b>	-6.39	<b>-0.0138</b>	-17.22
Loan amount 4 to 5 lakh	<b>-0.0341</b>	-6.17	<b>-0.0159</b>	-15.72
Loan amount 5 to 7 lakh	<b>-0.0381</b>	-6.21	<b>-0.0184</b>	-15.25
Loan amount 7 to 10 lakh	<b>-0.0385</b>	-6.63	<b>-0.0217</b>	-14.13
Loan amount 10 to 15 lakh	<b>-0.0421</b>	-6.82	<b>-0.0242</b>	-12.70
Loan amount 15 to 20 lakh	<b>-0.0465</b>	-7.34	<b>-0.0260</b>	-12.03
Loan amount 20 to 40 lakh	<b>-0.0446</b>	-7.96	<b>-0.0273</b>	-11.37
Loan amount over 40 lakh	<b>-0.0530</b>	-6.85	<b>-0.0280</b>	-12.25
Dummy: HSC Equivalent	<b>-0.0106</b>	-11.07	<b>-0.0046</b>	-14.06
Dummy: BA Equivalent	<b>-0.0154</b>	-8.34	<b>-0.0072</b>	-15.12
Dummy: Post-Grad Equivalent	<b>-0.0212</b>	-6.80	<b>-0.0105</b>	-11.59
Dummy: Qualification Missing or Unidentified	<b>-0.0025</b>	-2.27	<b>-0.0021</b>	-4.24
Dummy: Finance-Related Qual	<b>0.0026</b>	3.60	<b>0.0018</b>	5.33
Dummy: Loan administered through employers	0.0002	0.10	<b>-0.0033</b>	-2.82
Dummy: Usually Paid by Salary Deduction	<b>-0.0342</b>	-5.87	<b>-0.0170</b>	-10.19
Dummy: Tranched Issuance	0.0007	0.37	<b>-0.0020</b>	-2.80
Dummy: Loan is a Refinancing	<b>0.0044</b>	3.32	<b>0.0037</b>	3.81
Dummy: Loan is for a Home Extension	<b>-0.0041</b>	-3.15	<b>-0.0015</b>	-3.51
Dummy: Loan is for a Home Improvement	<b>0.0041</b>	2.38	<b>0.0022</b>	2.36
Dummy: 6 to 10 Year Loan	<b>0.0192</b>	4.37	<b>0.0032</b>	4.20
Dummy: 11 to 15 Year Loan	<b>0.0255</b>	4.95	<b>0.0079</b>	6.08
Dummy: 16 Year+ Loan	<b>0.0226</b>	5.60	<b>0.0139</b>	4.78
Cohort-Year Dummies?	Yes		Yes	
Branch Dummies?	Yes		Yes	
N_Obs	944,731		5,288,381	
R-squared	0.0188		0.0090	