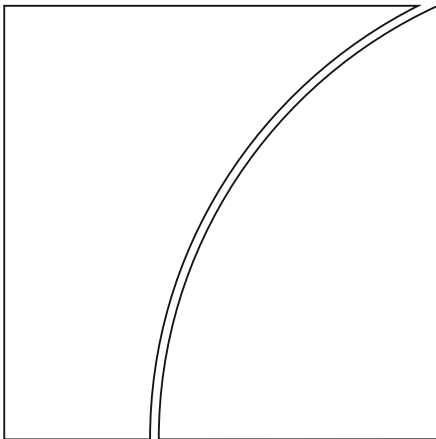




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# Loan-to-value policy and housing finance: effects on constrained borrowers

by Douglas Kiarely Godoy de Araujo, Joao Barata Ribeiro Blanco Barroso and Rodrigo Barbone Gonzalez

Monetary and Economic Department

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Keywords: LTV, loan-to-value ratio, mortgage, credit register, housing loans, macroprudential policy

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# Loan-to-value policy and housing finance: effects on constrained borrowers<sup>1</sup>

Douglas Kiarely Godoy de Araujo,<sup>2</sup> Joao Barata Ribeiro Blanco Barroso<sup>3</sup> and Rodrigo Barbone Gonzalez<sup>4</sup>

## Abstract

This paper explores the effects on constrained borrowers of an LTV limit implemented on September 2013 on two major segments of housing finance in Brazil. LTV (hard) limits and related policies entail identification challenges, since constrained individuals are no longer directly observed after policy implementation. In this paper, partially observed treatment status is overcome by the use of an adjusted difference-in-difference method, focusing on the average treatment effect on the treated borrowers (i.e. those that would violate the LTV limit if allowed to do so). We use comprehensive loan-level data on mortgages augmented with a detailed and granular employment register. In the most affected segment, constrained individuals must meet the new LTV limit. These treated borrowers purchase more affordable homes and are less likely to be in arrears 12 months in the future. In the least affected segment, constrained borrowers also end-up meeting the new LTV limit, but the impacts are smaller and we find no significant effects on borrower's housing choice or morose debt.

Keywords: LTV, loan-to-value ratio, mortgage, credit register, housing loans, macroprudential policy

JEL Classification: G21, G28

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# 1. Introduction

Macroprudential policies related to housing finance represent a relevant share of the macroprudential tools used in several jurisdictions. One of the most common policies targeting the housing sector is loan-to-value (LTV) limits for housing loans (Crowe et al., 2013). The higher equity stake and lower leverage required by these policies are designed to increase borrower resilience and to lower bank losses during downturns. These expected effects of the policy are consistent with theoretical models (e.g. Campbell and Cocco (2003)) and empirical evidence (e.g. Demyanyk and Van Hemert (2011)). However, important transmission channels of LTV limits have not been explored in the literature, particularly at the loan level, including its implications to financial stability (i.e., delinquency levels) and on families' housing choice.

We argue that imposing LTV limits may endogenously shift several characteristics of the loan contract and therefore influence borrower's behavior. As a result, otherwise highly leveraged households (or houses with high propensity to such behavior) may settle with different loan terms, face different housing choices, and repayment incentives.

This paper contributes to the literature by concentrating exactly on these changes in borrower behavior following the implementation of an LTV limit. More specifically, we focus on the effect of the policy on the subset of borrowers that are constrained by the policy (treated group); and we estimate the average treatment effect on the treated borrowers (ATT). However, the estimation of this effect requires a novel identification strategy. In our setting, it is natural to define constrained borrowers as the ones that would violate the LTV limit if allowed to do so. Since treatment status (i.e. taking LTV higher than the limit) is observed only before the policy, this creates an identification challenge. To overcome this, prior data on borrowers' characteristics is used to estimate the propensity of borrowers to take high LTV loans (and, therefore, be constrained by the regulation after the shock). This probability is used to instrument ATT parameters and estimate the effects after policy implementation. Botosaru and Gutierrez (2017) propose consistent and efficient estimators for the case of partially observed treatment status. We rely on their two-stage estimator to recover the ATT of LTV limits imposed in Brazil.

On September of 2013, the Brazilian banking regulator National Monetary Council edited a regulation establishing an LTV limit for a major share of housing loans in Brazil, a subsidized housing loan segment called "SFH"<sup>5</sup>. This segment is mainly used by the middle class. The LTV limit is also contemporaneously adopted in the "FGTS" segment, a collection of housing loans directed to low- and middle-income households. We consider these two segments of housing finance and conduct independent estimations for each one. The main difference between both segments is the eligibility criteria, based on different house price ceilings and on borrower income (the latter only in FGTS).

We use loan-level data from Central Bank of Brazil credit registry (SCR) and merge this data with the official employment registry from Ministry of Labor and Employment to augment the set of borrower control variables, including wage, job type, age, years of education, job sector and tenure on current job. The dataset has

<sup>5</sup> Portuguese acronym for Housing Finance System.

over 1.3 million loans spanning a three-year window around this policy change, but we restrict the empirical analysis to subsets of this data for better identification.

In addition to the LTV limit, the same regulation increased the price eligibility ceiling in SFH and rephrased the need for sound underwriting practices for all mortgages<sup>6</sup>. We avoid confusion between the LTV limit and the increased eligibility by restrict our samples to borrowers that finance homes priced below the previous eligibility ceiling. To overcome possible confusion with the underwriting practices required in the regulation, we estimate the results using only borrowers that have formal employment, and therefore documented income sources that facilitate the credit risk analysis by lenders. The repetition of the experiment in two relatively independent segments offers a rare opportunity to compare the estimated effects.

We find evidence that treated borrowers in the SFH segment purchase more affordable houses, and are less likely to be in arrears 12 months into the future. In the FGTS segment, where average LTV was lower and where high LTV was rare, we do not find these ATT effects to be significant.

These results document microeconomic effects of macroprudential policy on housing finance. Our empirical approach is novel and particularly relevant to academics and policy-makers challenged to impose hard limits. The methodology we present in this paper can be easily adapted to any of these events allowing assessment of their impacts using loan-level data.

A growing number of macroprudential interventions in housing finance create a variety of policy shocks, whose effects are still to be explored using loan-level data. Indeed, most countries have some form of explicit or implicit LTV policy on housing finance (Cerutti et al. (2015)), but the international experience is quite heterogeneous (e.g. Darbar and Wu (2015), Akinci and Olmstead-Rumsey (2015)). Some jurisdictions implement simple and hard LTV limits (as in this case of Brazil), while others combine policies such as taxation and capital requirements; there are also cases of LTV limits to certain house price buckets or specific geographical regions.

Using loan-level data from the US, Duca et al. (2011) find that higher LTV at origination cointegrates with higher house price-to-rent ratios between 1979 and 2007. Focusing on macroprudential policy but using more aggregated data, Igan and Kang (2011) find that the tightening of the LTV cap in South Korea results in lower transaction activity and lower house price growth. However, two cross-country studies, Jacome and Mitra (2011) and Darbar and Wu (2015), do not find effects on house prices to be significant.

Demyanyk and Van Hemert (2011) find that high-LTV loans originated in the run-up to the US subprime crisis were more likely to be delinquent during the bust. Hallissey et al. (2014) document the same effect in Ireland, where mortgages with higher LTV and loan-to-income (LTI) ratios at origination were more likely to be in arrears in the future. The empirical literature most closely related to this paper, Campbell et al. (2015), find that risk weights conditional on LTV in India reduced loan delinquencies. Although these results suggest that hard LTV limits could reduce

<sup>6</sup> This aspect is motivated by the report FSB principles for sound residential mortgage underwriting practices from April, 2012. All FSB country-members are asked to revisit such practices and draw specific regulations. However, all these practices were already required by previous regulations for loans (in general), e.g. Resolution 2,682/99 and Resolution 3,721/09. The BCB bank supervision reports that the underwriting practices were sound at that time and; apart from the LTV limit, they did not expect and report changes in these practices.

mortgage risk; to the best of our knowledge, there is no evidence of the effects of a policy shock of this nature using loan-level data, or of any “hard limit” policy, as explored in this paper.

As in Campbell et al. (2015), we find that the hard-LTV policy introduced in Brazil reduced the delinquency levels of new housing loans taken by treated households. We also find that the policy had economically and statistically significant underlying effects on treated borrowers’ housing choice. On average, treated SFH borrowers that financed a house after the shock choose homes that are 29% to 35% cheaper and still borrow at the new LTV ceiling.

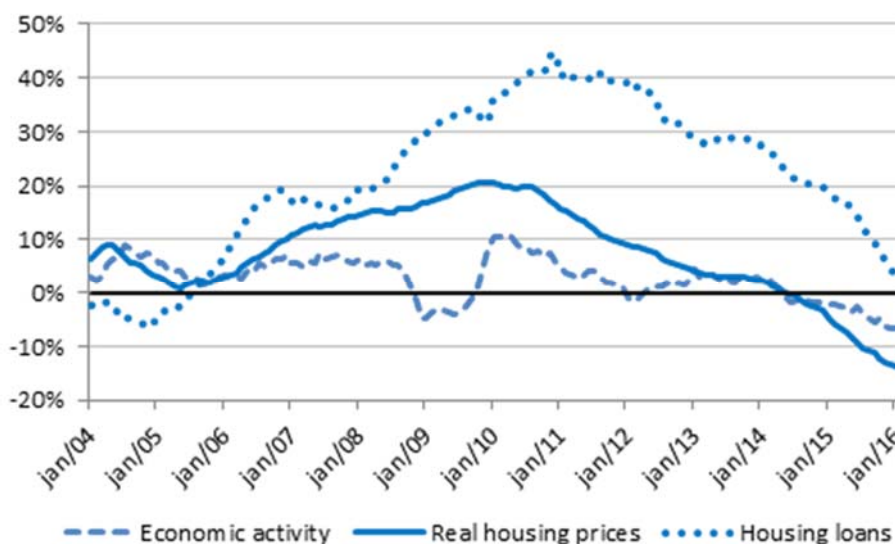
## 2. A Primer on Housing Finance in Brazil

According to Cerutti et al. (2015), Brazil is one of the jurisdictions that experienced a credit boom in the aftermath of the financial crisis. Housing finance in Brazil grew significantly since 2001, from less than 1% of GDP to 7% in 2013, while delinquency rates decreased from 7% to 1.6% between 2004 and 2013. Pereira da Silva and Harris (2012) largely attribute this development to the legal improvements that promoted faster repossession processes, and helped unlock the supply of housing loans. Figure 1 shows GDP growth, housing credit growth and real housing prices in Brazil.

Economic activity, housing loans, and housing prices in Brazil, 2004-2015.

All series are real annual growth rates.

Figure 1



Source: Central Bank of Brazil

The banking regulator formally implemented the FSB Principles on Sound Residential Mortgage Underwriting Practices and responded to these developments by requiring lenders to follow stricter borrower monitoring processes for all housing loans, as well as by implementing an LTV limit to a particular segment of the housing finance market (SFH). Before detailing this LTV regulation, we highlight some important features of housing finance in Brazil.

The main lender in the housing finance market is the government-owned Caixa Econômica Federal (henceforth CEF), with a large but declining market share of 74.0% as of December 2015. CEF is widely considered to be specialized in housing loans, and has wide geographical coverage in Brazil. Other large banks in Brazil (Itaú, BB, Santander and Bradesco) are also important lenders, representing together 23.3% of the mortgage market. These other banks have a more universal bank profile, and have only recently began to allocate shares of their credit portfolios into housing finance. In Brazil, not only are the major lenders domestically-owned (the largest exception, Santander, has a 5.2% market share), but virtually all borrowers are domestic residents, and the loans are all denominated in local currency.

Housing loans in Brazil enjoy significant subsidy, which varies according to the funding source and borrower characteristics. Interest rates are subsidized, subject to borrowers meeting eligibility criteria for that particular subsidy. The most relevant segment is "SFH". Deposit-taking institutions are required to channel a specific percentage of all resources deposited in Savings accounts to SFH housing loans<sup>7</sup>. The vast majority of new SFH housing loans are non-recourse, compensated with a faster repossession process in case of default. Traditionally, most housing loans follow a constant amortization schedule<sup>8</sup>. SFH housing loans are not backed by governmental agencies, and interest rates are not deductible for tax purposes. The SFH segment also allows workers with formal private-sector employment contracts to frontload social contributions made by their employers as down payment<sup>9</sup>.

SFH loans are available to prospective borrowers of their first house and that are not homeowners in the same city. They are expected to borrow for residential purposes, and the house price must respect a maximum eligibility ceiling.

This ceiling changes over time to accommodate changes in house prices. In fact, the same regulation that enacted the LTV limit also increased the eligibility price ceiling from BRL 500,000 up to BRL 750,000 (pending on geographical location). As a reference, these values represent 21.9 and 32.8 times the median annual income in September, 2013.

We call the second segment "FGTS", because it is a collection of various segments which share broadly similar funding and eligibility characteristics and are regulated by CCFGTS, the FGTS rulemaking council. The FGTS segment has lower interest rates than SFH; but unlike SFH, the borrower must meet a maximum income limit. FGTS and SFH were historically designed to foster homeownership to certain social strata, such as low-income or low-to-middle income classes, respectively. The most noticeable example of FGTS-segment is the program "Minha Casa Minha Vida (MCMV)", particularly because it offers very low interest rates.

Unlike other jurisdictions, which incentivize housing loans by tax deductibility or other similar policies, in Brazil, the nature of the subsidy is on interest rates. Funds are

<sup>7</sup> Savings accounts are widely-spread retail deposits yielding indexed to a base rate (Taxa Referencial – TR) that is correlated to inflation. SFH contracts are mostly indexed to TR

<sup>8</sup> The LTV limit that we study, 90%, is valid for loans with this amortization schedule. Other amortization schedules, which are less prudent, were limited to a maximum of 80%. The relevance of these loans is not considered material for the period of our analyses.

<sup>9</sup> This social contribution is a linear function of the wage earned, and is deposited by the employer in employee-specific accounts at the FGTS fund. These FGTS funds are used to fund several social benefits and also to fund alternative housing projects, generally known as "FGTS" segment.

(forcedly) redirected from savings accounts (SFH) or provided by the social security fund FGTS, but credit risk is carried solely by the banks operating these lines. In the case of SFH loans, banks (either private or public) are able to set a spread over the subsidized interest rate. In practice, the interest rates of SFH loans lay between their funding cost (i.e., the yield on savings accounts, which is approximately 6%) and the maximum rate allowed in the credit segment (approximately 12%)<sup>10</sup>.

The only housing loan segment that could offer better terms than the SFH is the FGTS segment. Borrowers that are not eligible for either segment – due to the price of the desired home, or willingness to finance a second unit, for example – have the outside option of a less regulated contract generally known as SFI<sup>11</sup>, with market interest rates. Overall, borrowers are strictly better by opting for a SFH loan if they are eligible, unless they are also eligible to a FGTS loan.

There are few similarities and remarkable differences between the Brazilian and the U.S. mortgage market. To certain extent, SFH and FGTS loans are somewhat comparable to conforming agency loans in the U.S., which require a minimum level of documentation from borrowers and also impose eligibility criteria. Some housing loan programs that we consider within the FGTS segment are quite comparable to FHA loans, since they are directed towards lower-income households that satisfy a number of criteria. Alternatively, SFI would be more comparable to “jumbo” loans.

On the other hand; as mentioned before, in Brazil, government subsidy on housing finance is on interest rates and not carried by loan insurance or stimulus for secondary markets. The regulated (subsidized) interest rates applicable to the SFH and FGTS loans are often lower than the yield of sovereign bonds, providing a significant incentive for households to borrow in either segment, if eligible, but the risks lie with the banks operating these three segments<sup>12</sup>. Indeed, the market for Residential Mortgage Backed Securities (RMBS) is negligible. As noticed before, the biggest player in the housing finance market is a public institution, CEF, but apart from this aspect, there is no other similarity with Fannie Mae and Freddie Mac. More importantly, CEF is a bank subject to the same prudential rules and supervision that any other bank, while the two latter institutions are regulated by the Federal Housing Finance Agency and not subjected to capital regulation.

## LTV limit

In the context of the growth in housing prices in Brazil, the National Monetary Council (CMN)<sup>13</sup>, introduced Resolution n. 4,271/2013 (CMN, 2013; henceforth “Resolution”) in September, 2013. The Resolution required that SFH loans have a maximum LTV of

<sup>10</sup> In practice, there is also a variable rate (Taxa de referência, or TR) that is equally added to both savings and SFH housing loan rates. Banks have effectively very little room to set those spreads.

<sup>11</sup> In this third segment, the number of SFI operations reaches a few thousands representing a tiny share of the housing finance. SFI is still partially subsidized by savings accounts, but banks can set their interest rates freely

<sup>12</sup> In one very specific FGTS program (e.g., MCMV “phase” 1), the Treasury is directly responsible to make-up for losses incurred by the banks.

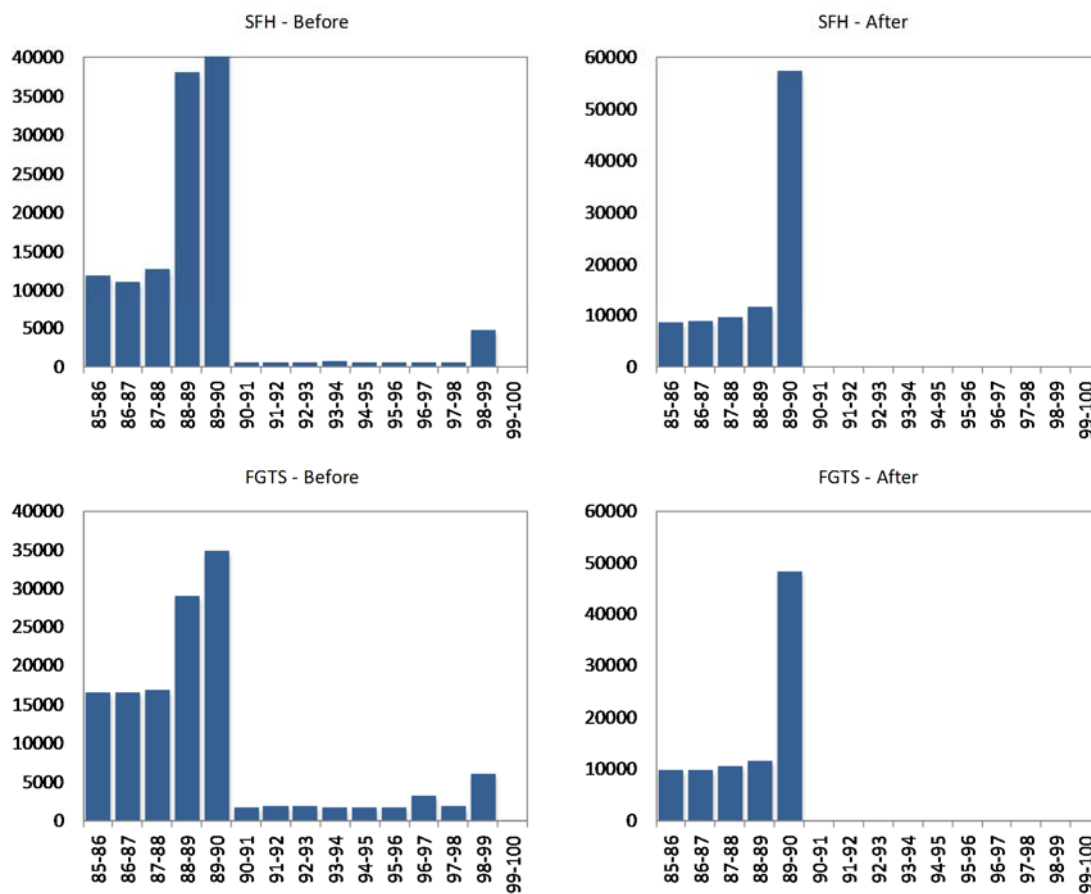
<sup>13</sup> The CMN is the main regulator of the financial system. The three members of the CMN are the Minister of Finance (Chairman), the Minister of Planning, Budget, and Management, and the Governor of the Central Bank of Brazil.



90%<sup>14</sup>. Home equity lines of credit were also limited to a 60% LTV. Segments other than SFH are not addressed by the regulation and not mandated to comply with LTV limits. However, the council regulating FGTS voluntarily decided to comply to this limit with immediate effects<sup>15</sup>. Figure 2 illustrates the distribution of LTVs of new housing loans originated before the LTV regulation (January 2012 to September 2013) and after the regulation (until December 2014). Considering this fact, and the economic importance of the FGTS segment, we also incorporate it in our analyses. Observe that the share of loans with LTVs higher than 90% was effectively small prior to the resolution, but quickly increasing in the past year. In the SFH, when high LTV loans were originated, they were closer to 100% LTV, whereas in the FGTS, the cases were more scattered between the range of 90 to 100% LTV.

Frequency of new housing loans by LTV ranges.

Figure 2



<sup>14</sup> The limit applies to loans using constant amortization (CAM), i.e., the vast majority in Brazil. For other products, the limit is 80%.

<sup>15</sup> The CCFGTS is a council composed of the many different stakeholders in the FGTS, including a representative of the BCB. The proposal to incorporate the maximum LTV rule of 90% came from the representative of the Ministry of Cities (who is also the deputy chairperson of the CCFGTS), not from the BCB representative. Moreover, the decision to establish the same LTV limits as the SFH can be traced directly to the prudential limit established by the CMN Resolution, as can be seen in the CCFGTS meetings minutes.

Finally, it is important to highlight that the new regulation was unexpected to market participants.<sup>16</sup> It is important to notice that regulators did not use hard LTV limits in Brazil ever before. Prior macroprudential regulation strongly favored regulatory capital measures using risk weights (e.g. as a function of LTV or maturity for auto loans)<sup>17</sup>.

In addition to the LTV limit for the SFH segment, the Resolution required lenders to follow sound underwriting practices in line with the FSB Principles for Sound Residential Mortgage Underwriting Practices (FSB, 2012) for all housing loan segments (FGTS, SFH or SFI). In this regard, Resolution 2,682/99 and Resolution 3,721/2009 already required documentation and origination standards to be met. Resolution n. 4,271/2013 follows FSB recommendations to pass a specific regulation about mortgages. However, to our understanding, other than the LTV limit, none of the requirements outlined in the norm was new to banks. However, we restrict our sample to formally employed individuals to avoid concerns about risk shifting towards individuals with better documentation.

### 3. Methodology and data

This section presents the identification strategy and data description. We use the differences-in-difference estimator described by Botosaru and Gutierrez (2017); the reader is referred to their paper for further details on the estimator.

We define treated borrowers as the ones that would violate the LTV limit if allowed to do so. Consider two periods  $t \in \{0,1\}$  representing a set of months before the policy and after the policy, respectively. Each borrower has two potential outcomes:  $Y_t(1)$  if exposed to treatment and  $Y_t(0)$  if not exposed. The outcomes in our empirical application refer to borrower repayment behavior 12 months in the future, the LTV itself, and house price.

We can observe the treatment status of the borrowers only before the macroprudential regulation of September, 2013. Treated borrowers are defined as those with LTV greater than the limit of 90%. They are directly observable before the policy. After this shock, we can no longer directly distinguish the “constrained” borrowers, because “would-be high LTV borrowers” that effectively get a housing loan will be constrained into lower LTV outcomes in the future. The methodology by Botosaru and Gutierrez (2017) is particularly designed for similar cases, where the treatment status is only partially available.

Let  $D \in \{0,1\}$  represent treatment status, which is only observed in  $t = 0$ , i.e.  $Y_1$  represent individuals in  $t=1$  and  $Y_0$  individuals before the shock ( $t=0$ ). The parameter of interest is the average treatment effect on the treated (ATT), defined by  $ATT \equiv E(Y_1(1) - Y_1(0)|D = 1)$ . If treatment status were observed in both periods,

<sup>16</sup> A simple correlation exercise suggests that there was no frontloading of housing loans ahead of the policy action. The correlation between the relevance of high-LTV loans and the increase in number of originations in each of the 27 Brazilian states is very close to zero or even negative, depending on the time frame used.

<sup>17</sup> For example, see Martins and Schechtman (2013) and Afanasieff et al. (2015) for background and estimates for the impact of shifts in risk weights in auto loans made conditionally on loan maturity.

under usual identifying assumptions, the parameter would be identified by  $\theta \equiv [E(Y_1|D = 1) - E(Y_0|D = 1)] - [E(Y_1|D = 0) - E(Y_0|D = 0)]$ .

The usual assumptions we refer to are (A1) parallel paths for treated and control group and (A2) no anticipation of the policy change. Our empirical strategy to ensure that both trends are parallel is to compare treated borrowers with non-treated borrowers with similar LTV levels, at different cutoff levels. Hence, our results are robust only to the range of underlying LTVs considered in the analysis.

Because we have partially-observed treatment status, a proxy variable for treatment status ( $D = 1$ ) is needed. Let  $Z$  be a time invariant variable observed in both periods and consider the propensity score  $e_t(Z) \equiv Prob_t(D = 1|Z)$ . Consider the following additional assumptions: (A3) stationarity,  $e_0(Z) = e_1(Z) \equiv e(Z)$ , meaning the policy (or other time-varying outcomes) do not affect the propensity score within the relevant period; (A4) relevance,  $e(z_1) \neq e(z_2)$  for some  $z_1$  and  $z_2$ , meaning the proxy variable is actually relevant to forecast treatment status; (A5) conditional independence,  $E(Y_1(D)|D, Z) - E(Y_0(D)|D, Z) = E(Y_1(D)|D) - E(Y_0(D)|D)$ , meaning that, conditionally on treatment status, the proxy variable may only affect outcomes homogeneously in both periods.

We consider wage<sup>18</sup> as the ( $Z$ ) proxy variable for the first stage (i.e. the propensity score). Wage should have an impact on the propensity to leverage and this relation should not be time-varying in the relevant time frame, at least as long as other joint determinants, such as debt levels, are not substantially different between the two periods for a specific candidate borrower. Additionally, we estimate the results in the subsample that has formal employment contracts; for these borrowers, income documentation is significantly easier than for other prospective borrowers. Since the Resolution requires more sound underwriting practices from lenders, including enhanced documentation procedures, we expect that this shift in risk management will not affect the relationship between a person's wage (conditional on being a formal employment relationship) and her propensity to borrow with high LTV. From another, less structural perspective, we can also postulate the assumptions hold by definition, since we are considering a counterfactual definition of treated borrowers as the ones that would have behaved in a certain direction in the past.

Botosaru and Gutierrez (2017) show that, for partially observed treatment status, assumptions A1-5 are sufficient to identify the ATT parameter. The result is simple. Let  $\Delta E(Y|\cdot) \equiv E(Y_1|\cdot) - E(Y_0|\cdot)$ . It is clear that  $\Delta E(Y|Z) \equiv \Delta E(Y|Z, D = 1)e(Z) + \Delta E(Y|Z, D = 0)(1 - e(Z))$ . Using the conditional independence assumption,  $\Delta E(Y|Z) \equiv \Delta E(Y|D = 1)e(Z) + \Delta E(Y|D = 0)(1 - e(Z))$ . Stack this expression  $K$  times, one for each value  $\{z_k\}_{k=1..K}$  in the support of the proxy variable. This results in a linear system that can be solved for  $\Delta E(Y|D = 1)$  and  $\Delta E(Y|D = 0)$ , and therefore also for the  $\theta$  which identifies the ATT parameter.

The estimator they propose is just the sample analog of these stacked system considering the realized values of the proxy variable. Notice that this estimator, as in traditional differences-in-difference estimation, applies to a repeated cross-section sample, which is the case of our dataset, as different borrowers enter housing loan contracts at each date. Botosaru and Gutierrez (2017) also show that this is numerically equivalent to a just-identified GMM estimator. The proposed GMM

<sup>18</sup> As detailed below, the source of wage information is the RAIS, the granular and detailed government employment register.

moment conditions allows one to deduce the asymptotic variance of the ATT parameter taking into account the uncertainty in the first step propensity score estimation. Our results are all based on this GMM estimator and associated asymptotic inference.

Botosaru and Gutierrez also show in Monte Carlo experiments and applications that results are not sensitive to the model specification in the first stage, which can be performed by an ordinary least squares, probit, or logit model. They also argue that the F-statistic of the first-stage regression should corroborate strongly the relevance assumption for the proxy variable. When presenting our results, we emphasize the F-statistic of the first stage, focusing on the OLS estimation of the propensity score<sup>19</sup>.

The methodology is designed to estimate the effect of a single policy intervention. In our application, the regulator also increased the price eligibility cap of the SFH housing loan segment, in addition to the establishment of the LTV limit in the same segment (followed by the same limit in FGTS loans). To avoid confounding effects of the increase in the SFH home price eligibility ceiling, we only estimate the models with the subset of loans for which the home price was below BRL 450,000 (i.e. below the previous limit of BRL 500,000 both before and after September, 2013).

## 4. Data

The Credit Information System (SCR), the credit register managed by Central Bank of Brazil (BCB), centralizes information about loans, endorsements, and lines of credit granted by all Brazilian financial institutions to individuals and corporate entities<sup>20</sup>. The SCR comprises characteristics of the borrower, the debt contract, and the collateral; this information undergoes rigorous verification processes to ensure quality and consistency. In practice, the SCR is extensively used both for supervisory purposes by the BCB, and by financial institutions, when assessing the risk of prospective borrowers. Table 1 summarizes the information we use from the SCR regarding all housing loans originated in the years 2012 to 2014 and Table 2 restricts this sample to housing originations over the LTV of 80%. Apart from an increase in financed house prices close to 14% on FGTS and 5% on SFH in this period, we do not notice any other significant change. Note that this change in house price is common to both individuals taking loans with LTV over 80% (Table 2) and the population (Table 1). In Table 1, the aforementioned differences on interest rates and house prices between SFH and FGTS become clear as SFH is a typical medium class segment.

<sup>19</sup> Since the first-stage results with the OLS technique are able to successfully discriminate the propensity for taking loans with LTV higher than 90%.

<sup>20</sup> The minimum threshold for granular information in the SCR is BRL 1,000 outstanding per borrower in each reporting month. Since this amount is very low for housing finance, for practical reasons all housing loans in Brazil are granularly detailed.

Housing loans in Brazil, Jan/12 to Dec/14.

Table 1

SFH segment (Before the Policy Shock)						N = 229,021
	<b>Mean</b>	<b>St. Dev.</b>	<b>25%</b>	<b>50%</b>	<b>75%</b>	
Loan (BRL)	148,368	66,337	100,000	138,000	184,500	
House price (BRL)	224,947	90,843	155,000	210,213	283,591	
Interest rate (%)	8.98	0.65	8.85	8.85	8.85	
Maturity (years)	26.44	8.01	20.17	30.00	33.83	
SFH segment (After the Policy Shock)						N = 157,236
	<b>Mean</b>	<b>St. Dev.</b>	<b>25%</b>	<b>50%</b>	<b>75%</b>	
Loan (BRL)	160,990	66,726	112,800	151,000	200,000	
House price (BRL)	235,763	88,625	167,688	222,231	297,579	
Interest rate (%)	8.95	0.44	8.85	8.85	9.14	
Maturity (years)	28.71	7.60	25.00	30.00	35.00	
FGTS segment (Before the Policy Shock)						N = 279,200
	<b>Mean</b>	<b>St. Dev.</b>	<b>25%</b>	<b>50%</b>	<b>75%</b>	
Loan (BRL)	78,201	22,441	64,000	77,016	91,000	
House price (BRL)	107,869	30,272	85,917	101,257	127,325	
Interest rate (%)	5.36	1.09	4.59	4.59	5.64	
Maturity (years)	25.64	3.75	25.00	25.00	30.00	
FGTS segment (After the Policy Shock)						N = 167,763
	<b>Mean</b>	<b>St. Dev.</b>	<b>25%</b>	<b>50%</b>	<b>75%</b>	
Loan (BRL)	89,896	26,727	73,448	87,887	104,000	
House price (BRL)	121,815	35,548	95,486	115,858	141,572	
Interest rate (%)	5.43	1.03	4.59	5.11	5.64	
Maturity (years)	28.54	3.51	30.00	30.00	30.00	

Descriptive statistics of housing loans of the SFH and FGTS segments originated in Brazil before and after the LTV limit in September 2013. Only housing loans financing homes priced lower than BRL 450,000 are considered.

We merge loan-level information from the SCR with RAIS, the official employment register of the Brazilian Ministry of Labor and Employment. This database contains information about each natural person that has at least one documented employment relationship in Brazil in a given year, as well as other related information about the employer and their employment contract. These data includes gender, age, years of education, wage, tenure at current employment, job type, and the economic sector of the employer. Table 3 compares borrower characteristics before and after the Resolution, illustrating the fundamental similarity of borrowers in both periods for each housing loan segment. Notice that 0.73% of formal employees originated a housing loan in SFH before the shock, whereas 0.18% originated loans with LTVs higher than 85% and a 0.02% initiated loans higher than 90% between January 2012 and September 2013 (Table 3).

Housing loans in Brazil, Jan/12 to Dec/14 (LTV&gt;80%).

Table 2

SFH segment (Before the Policy Shock)						N = 78,583
	<b>Mean</b>	<b>St. Dev.</b>	<b>25%</b>	<b>50%</b>	<b>75%</b>	
Loan (BRL)	167,999	72,756	117,000	153,000	207,000	
House price (BRL)	193,021	83,486	133,420	176,873	239,573	
Interest rate (%)	9.08	0.59	8.85	8.85	8.85	
Maturity (years)	28.95	6.68	25.00	30.00	35.00	
SFH segment (After the Policy Shock)						N = 59,357
	<b>Mean</b>	<b>St. Dev.</b>	<b>25%</b>	<b>50%</b>	<b>75%</b>	
Loan (BRL)	178,447	70,125	128,800	165,000	218,725	
House price (BRL)	206,043	81,331	147,305	191,005	251,970	
Interest rate (%)	9.04	0.37	8.85	9.14	9.14	
Maturity (years)	30.78	6.19	29.17	35.00	35.00	
FGTS segment (Before the Policy Shock)						N=90,764
	<b>Mean</b>	<b>St. Dev.</b>	<b>25%</b>	<b>50%</b>	<b>75%</b>	
Loan (BRL)	83,792	20,221	71,099	81,416	93,339	
House price (BRL)	96,842	23,563	80,851	95,140	108,307	
Interest rate (%)	5.48	1.10	4.59	5.11	5.64	
Maturity (years)	23.99	2.58	24.92	25.00	25.00	
FGTS segment (After the Policy Shock)						N=54,260
	<b>Mean</b>	<b>St. Dev.</b>	<b>25%</b>	<b>50%</b>	<b>75%</b>	
Loan (BRL)	95,825	25,873	79,110	90,068	109,692	
House price (BRL)	110,968	30,322	90,365	105,783	127,786	
Interest rate (%)	5.69	1.05	4.59	5.64	6.86	
Maturity (years)	28.20	3.28	25.00	30.00	30.00	

Descriptive statistics of housing loans of the SFH and FGTS segments originated in Brazil before and after the LTV limit in September 2013. Only housing loans financing homes priced lower than BRL 450,000 and LTV higher than 80% are considered.

Self-employed individuals, business owners, and undocumented workers are not listed in the RAIS database and we have very limited information about them (e.g. an ordinal income proxy and city of residence). For this reason, we restrict our analyses to individuals with documented working relationships, for which there is information in RAIS. As mentioned before, by analyzing this subset we also avoid concerns with different underwriting practices between borrowers with income documentation and others. Also, additional borrower-level control variables are used in the first-stage estimates.

## Characteristics of borrowers before and after the Resolution

Table 3

<b>SFH:</b>	<b>Jan/12 to Sep/13</b>	<b>Oct/13 to Dec/14</b>
Monthly income (BRL)	7,505.34	7,638.56
Education (years)	8.22	8.18
Tenure at current job (years)	8.83	8.78
Women (%)	35.68	36.71
Gov. Employee (%)	32.25	32.03
Number of borrowers to total formal employment (%)	0.73	0.50
of which (%) had LTV > 85%	0.18	0.13
of which (%) had LTV > 90%	0.02	0.00
Number of contracts	229,021	157,236
<b>FGTS:</b>	<b>Jan/12 to Sep/13</b>	<b>Oct/13 to Dec/14</b>
Monthly income (BRL)	2,412.75	2,524.98
Education (years)	6.92	6.90
Tenure at current job (years)	5.27	5.13
Women (%)	35.93	36.92
Gov. Employee (%)	14.48	13.31
Number of borrowers to formal employees (%)	0.89	0.54
of which (%) had LTV > 85%	0.18	0.12
of which (%) had LTV > 90%	0.03	0.00
Number of contracts	161,558	147,672

Descriptive statistics for the sample restricted to borrowers with formal employment (private and public sectors) who financed homes priced below BRL 450,000. The different periods of January 2012 to September 2013 and of October 2013 to December 2014 discriminate the dates before and after the Resolution.

## 5. Results

The results for the SFH and FGTS segments are presented in Table 4. In all cases, we are interested in estimating the ATT. We present those for the following dependent variables: the LTV itself, the house price, the loan amount, and the probability of arrears in the first 12 months (“arrears” for brevity).

In both segments, the different LTV cutoff levels (across columns) restrain the sample of the treated group to the subsamples where LTVs are higher than the cutoff, but lower than 90%. In each column, the same subsample is used to estimate the propensity score (first-stage) and the ATT (second-stage). The reported F-value is related to the first-stage. All other figures in Table 4 relate to the second-stage. Notice that the F-value is always significant reflecting that, within the (treated) subsamples, the explanatory variable of the first-stage discriminate well the individuals with LTV higher than 90% prior to the shock.

Our preferred specifications have higher LTV cutoffs, represented in the last columns of Table 4, because individuals from these subsamples are a closer match to the “pseudo-individuals” we estimate. Notice that the F-value of the SFH estimates is

increasing despite the sharp drop in sample size. The disadvantages of these higher cutoff level estimates are related; the corresponding reduction in sample size comes with loss of both statistical and economical relevance.

Average treatment effect on constrained borrowers

Table 4

SFH segment	LTV > 80%	LTV > 85%	LTV > 87%	LTV > 88%
LTV (p.p.) <sup>1</sup>	-11.76*** (3.90)	-9.83*** (2.11)	-8.70*** (1.42)	-8.30*** (1.11)
House price (log)	-0.51*** (0.15)	-0.35*** (0.07)	-0.36*** (0.05)	-0.29*** (0.04)
Loan (log)	-0.63*** (0.65)	-0.46*** (0.50)	-0.45*** (0.44)	-0.38*** (0.40)
Probability of arrears (b.p.) <sup>2</sup>	-15.81*** (6.13)	-11.86*** (3.19)	-10.76*** (2.30)	-10.31*** (1.89)
F	2,077	2,139	2,127	2,135
N	137,940	97,924	79,416	69,246
FGTS segment	LTV > 80%	LTV > 85%	LTV > 87%	LTV > 88%
LTV (p.p.) /1	-8.35*** (0.98)	-5.37*** (0.47)	-4.70*** (0.35)	-4.54*** (0.30)
House price (log)	0.19*** (0.04)	0.07*** (0.02)	0.01 (0.02)	-0.02 (0.01)
Loan (log)	0.09***	0.01	-0.04***	-0.07***
Probability of arrears (b.p.) /2	-2.87** (1.11)	-0.42 (0.80)	-0.19 (0.74)	0.44 (0.70)
F	2,480	1,839	1,514	1,296
N	145,024	92,447	70,987	59,771

<sup>1</sup> Before the LTV limit, the average LTV for borrowers with LTV > 90% is 96.52% and 95.48% for the SFH and FGTS segments, respectively. Hence, the effect on the average LTV in each segment should be around 6.52 p.p. and 5.48 p.p. <sup>2</sup> This proxy for credit risk is the probability that the borrower will be in arrears for at least 15 days, in any period during the first 12 months of the loan contract.

Treated households have unconstrained LTV > 90%. The table reports the Botosaru and Gutierrez (2017) two-stage estimator. The first stage estimates the propensity score to LTV > 90% using the pre-regulation sample, conditioning on borrower income. F statistics reported in the table refer to the first-stage equation, confirming that treated borrowers are successfully identified. The second stage uses the propensities to identify the effect of interest. Standard errors take into account the first stage estimation uncertainty. Columns show results when defining the population of interest according to minimum LTV cutoff levels. The closer this minimum is to 90%, the more likely the parallel trends assumption implicit in the estimator holds. In all cases, the population of interest has house prices lower than BRL 450,000 to avoid confounding the effect of the LTV limit with the effect from the increase of house price eligibility cap. The sample is restricted to individuals with formal jobs that entered SFH or FGTS housing loans from January 2012 to December 2014. Controls include gender, years of education, tenure at current employment, dummy for public service employment, sector of employment, zip code.

As expected, the LTV limit causes a reduction in ATT of LTV, to a level that is consistent with the maximum allowed of 90%. This "redundant" estimate illustrates the novel methodology we use. Observe that results are in line with data on Figure 2. On SFH, the individuals with high LTV were, on average, closer to the 98-99% range of LTVs. On FGTS, these individuals were better scattered between 91 to 99%, reflecting the lower ATT on LTV for FGTS as compared to SFH, i.e. the treated group on SFH was more leveraged, on average, than the FGTS treated group. This probably corroborated with the prudential decision to target only the SFH segment. On both cases, the ATT on LTV is broadly consistent with Figure 2, where individuals on the



98-99% appear to be likely constrained to new maximum 89-90%, i.e. an average ATT close to 10% for SFH borrowers and 5% for FGTS. After the shock, households that could not adjust to the new rules (either by choosing a cheaper house, making a higher down payment than originally planned, or both) are simply not observed. To certain extent, our results may be seen as a lower bound for the total effects.

The main channel treated households take to adjust is the choice of a cheaper house. We estimate that treated SFH borrowers finance homes 29% to 35% cheaper than the counterfactual ("desired") home<sup>21</sup>. This result is both economically and statistically significant, and suggests houses actually purchased by the treated borrowers may be "qualitative" inferior. Several combinations of housing characteristics such as different location, renovations, lower number of bedrooms, distance from amenities, etc. could create a price differential of such magnitude. Suppose a household willing to finance a house worth BRL 200,000 with a down payment of BRL 2,000. After the shock, a down payment of BRL 20,000 may be "too far" from the original goal considering the financial constraints of the average treated household. However, settling with houses between BRL 130,000 to BRL 142,000, allows "suboptimal", but more viable down payments of BRL 13,000-14,000.<sup>22</sup>

The home choice channel is in line with results obtained independently<sup>23</sup> by Tzur-Ilan (2017) while studying the effects of a soft limit on LTV for housing loans in Israel. Using detailed home data, this author finds that affected borrowers purchase cheaper homes, located farther away from Tel Aviv, and in lower-graded neighborhoods.

Igan and Kang (2011) and Crowe et al. (2013) find that LTV policy influence house price's growth (as observed by ordinary indexes), whereas Jacome and Mitra (2011) and Darbar and Wu (2015) find no significant evidence of such effects. As a share of total new housing loans, the number of treated households in this paper is too small to consider aggregate effects of these magnitudes. However, using our methodology and loan-level data, it is possible to assess the treated households' housing choice in response to the LTV limit. This result is new in literature, but of different nature the aforementioned studies. To certain extent, our approach allows us to use individuals' heterogeneity to assess the average impact on the treated households even (as in this case) when these effects are small in aggregated terms, but largely significant to the treated household. On the other hand, finding aggregated level changes in house prices (i.e. changes in house-price indexes) would largely depend on the overall number of affected individuals. This is important to qualify the aforementioned studies.

The repayment behavior of treated SFH borrowers improves after the shock. Arrears<sup>24</sup> of the treated decreases by approximately 10.36 to 11.86 basis points, or on

<sup>21</sup> In a context of rising nominal housing prices, this fact may effectively result in qualitative differences between their desired and purchased homes.

<sup>22</sup> Still, such an increase in down payment is likely to cause families to postpone consumption needs related to the housing decision such as furniture and renovations. Alternatively, families may resort to other types of loans to alleviate these very needs. We leave this latter aspect for further studies.

<sup>23</sup> Tzur-Ilan's research is similar to our investigation about the effects of LTV policy on borrower decision using detailed micro-level data. One important difference is that the supervisory policy studied by Tzur-Ilan is a "soft limit": banks are not prohibited to extend housing loans above a certain LTV limit (60%); instead, they are subject to higher capital provisions for these loans.

<sup>24</sup> This proxy is the ex post probability of arrears of 15 days or more during the first twelve months of the loan. We have very few default observations and a too narrow evaluating window to stick to more "classic" default definitions such as arrears of 90 days or more. We refer to our proxy as Arrears.

average 5% (i.e. 10 over 200 bps. The treated average arrears rate prior to the shock is 200 bps). This result is statistically significant when controlling for several observable characteristics of the borrowers such as tenure at current employment, economic sector, level of education, age and other borrower and employment characteristics that may correlate with “job stability”, and consequently, repayment ability.

This result is in line with Campbell et al. (2015); that also find delinquency reduction after LTV policy using loan-level data, but novel for hard LTV limit policy.

In the FGTS segment, we could not find significant results either for house choice or arrears. This could be a consequence of an effectively “weaker” shock, but also due to a better risk profile of the treated households of FGTS as compared to those of SFH.

## 6. Conclusion

In this paper, we evaluate the impact of a LTV limit macroprudential policy on two segments of housing finance in Brazil, SFH and FGTS. In SFH (the most affected segment), we find that borrowers constrained by the new regulation (i.e. treated) choose cheaper houses and present improved repayment behavior. These results are statistically and economically significant. The treated SFH households choose houses 29% to 35% cheaper after the shock and are 5% less likely to be arrears 12 months into the future.

The methodology applied in this paper is novel and embedded in an adjusted two-stage difference-in-difference estimator to assess the average treated effect on the treated (ATT) when treatment status is partially observed. This novel identification strategy opens the floor to explore the impacts of “hard-limit” policies such as LTV and LTI limits on the constrained individuals using loan-level data. These types of macroprudential policy are both relevant and widespread, particularly for housing finance, and constitute an important part of the supervisory toolbox to contain the buildup of systemic risk (CGFS, 2012). The empirical approach suggested in the paper is therefore of broad relevance, and could be applied to study other policy interventions.

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