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Richard Cóndor
Banco de México

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Evaluating the Effects of the Home Affordable Modification Program*

Richard Cóndor†
Banco de México

Abstract: The Home Affordable Modification Program (HAMP) was a loan modification program introduced in 2009, in the U.S., to assist highly indebted homeowners with avoiding foreclosure. This program also encouraged private lenders to offer more sustainable modifications. This paper studies the role of HAMP in preventing higher foreclosures rates during and after the Great Recession, in the context of a general-equilibrium heterogeneous-agents model with two types of households (Borrowers and Savers), uninsurable idiosyncratic risk, and both private and HAMP modifications. The main result is that, without HAMP, the peak in the foreclosure rate could have been 50% larger (3.2 percent vs 2.2 percent in data).
Keywords: Housing policy, Heterogeneous agents, Financial Economics
JEL Classification: G51, E44, C61

Resumen: El Programa de Modificación de Viviendas Accesibles (HAMP por sus siglas en inglés) fue un programa de modificación de préstamos hipotecarios introducido en 2009, en EUA, para ayudar a los propietarios de viviendas altamente endeudados a evitar embargos hipotecarios. Dicho programa también alentó a bancos privados a ofrecer modificaciones con términos más favorable para los hogares. Este documento estudia el papel de HAMP en la prevención de tasas de embargo hipotecario más altas durante y después de la Gran Recesión, en el contexto de un modelo de equilibrio general con agentes heterogéneos, dos tipos de hogares (Prestatarios y Ahorradores), riesgo idiosincrásico no asegurable y modificaciones tanto privadas como de HAMP . El resultado principal es que, sin HAMP, el pico en la tasa de embargo hipotecario podría haber sido 50% mayor (3.2 por ciento frente al 2.2 por ciento en datos).
Palabras Clave: Política de vivienda, Agentes heterogéneos, Economía Financiera

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† Dirección General de Investigación Económica. Email: rcondorc@banxico.org.mx.

1 Introduction

The foreclosure rate in the U.S. increased sharply during and after the recession of 2008-2009.[1] While this rate was only 0.5 percent in 2005, it jumped to 1.8 percent in 2008, and reached a peak of 2.2 percent in 2010. Foreclosures are costly because, among other things, they imply deadweight losses for both homeowners and lenders. In addition, as the rate and sustainability of mortgage modifications during 2008 was considered insufficient, the federal government decided to introduce the Home Affordable Modification Program (HAMP) in 2009 to stimulate loan modifications.

HAMP offered homeowners who were at the risk of foreclosure, a reduction in their mortgage payments down to 31 percent of their income, by cutting the mortgage principal and/or the interest rate. Several requirements had to be met by homeowners to have access to the program, which included proving both financial hardship and the ability to make mortgage payments after the modification. Also, the program included economic incentives for both lenders and homeowners, so that modifying the loan was mutually beneficial. HAMP expired at the end of 2016.

Before HAMP, as Scott (2015) reports, private modifications mostly consisted in recapitalizing missed interest payments and recalculating the borrower's payments based on the new, higher mortgage loan balance, without taking into account the actual homeowner's capacity to make such new payments on time. Not surprisingly, modifications completed in 2007 and 2008 experienced high re-default rates in the early months following the modification.[2] In that sense, HAMP helped to set modification standards across the mortgage industry, and encouraged private lenders to modify mortgages in a more sustainable fashion, at no expense to taxpayers.[3]

This paper studies the role of HAMP in preventing higher than observed foreclosure rates during and after the Great Recession. More generally, it compares the benefits of the program against its costs. To that end, I consider an economy that goes through a financial recession that resembles that of 2008-2009, in which homeowners also have temporary access to either i) a tax-financed loan modification program similar to HAMP or ii) a less generous

[1] This recession was also characterized by a considerable contraction in both house prices and mortgage-debt-to-income ratios.

[2] See, for instance, OCC Mortgage Metrics Report, First Quarter 2009, p. 29, OCC, March 2009.

[3] See https://www.treasury.gov/initiatives/financial-stability/TARP-Programs/housing/mha/Pages/hamp.aspx for more details of the program.

private modification. Such economy is incorporated into a general equilibrium enviroment with housing, lack of commitment, and costly foreclosure. Then, I perform a counterfactual exercise in which HAMP is not available. In such scenario, I also assume that no private modification takes place.[4] The benefits of the program are then measured as the sum of avoided deadweight and house wealth losses, where 'avoided' refers to the difference between the 'no-HAMP' and 'HAMP' cases.

The model follows the tradition of Kiyotaki and Moore (1997) and Aiyagari (1994), in that it has two types of agents with different levels of patience, who are also subject to idiosyncratic income shocks.[5] In equilibrium, the average impatient household borrows (Borrower) whereas the average patient household saves (Saver). In addition, and departing from the two former papers, households cannot commit to honor their mortgage obligations: If they choose to default, they not only lose their housing stock but some fraction of their income as well.[6] I also introduce an idiosyncratic house depreciation (valuation) shock which, along with the lack of commitment and income shock, results in a fraction of households defaulting every period. Finally, all mortgages are one-period contracts.[7]

For simplicity, the economy is assumed to be initially in its stationary equilibrium in 2007.[8] This initial equilibrium is calibrated to match most of the moments observed in the U.S. during 2016, as many of the macroeconomic variables were close to or at their sample averages that year. A financial recession is then generated with two elements. First, aggregate income unexpectedly follows the path of the cyclical component of the real mean family income during the period 2008-2016. Second, the volatility of the idiosyncratic house valuation shock, fixed in the stationary equilibrium, increases unexpectedly along the transition path so that foreclosure rates in the model match those in data during that same period.[9]

The main finding is that, without the loan modification program, the peak in the foreclosure

[4]This assumption is consistent with the following intra-period chain of events: banks offer private modifications recapitalizing outstanding arrears, households accept them; however, they end up defaulting anyways.

[5]As in Aiyagari (1994), there is no aggregate uncertainty and the economy is closed.

[6]This income loss accounts for moving fares and other expenses after foreclosure. It is also a modelling device to make default negatively correlate with individual income, commonly used in the Sovereign Default literature. See, for instance, Arellano (2008).

[7]Results are qualitatively similar if long-term contracts are considered.

[8]A sensitivity analysis, presented in the Appendix section, explores how the foreclosure rate computed in the absence of HAMP would change if the economy in the model was not initially in its stationary equilibrium, like data clearly suggest for the year 2007. The results suggest that the assumption made in the main exercise is quantitatively harmless.

[9]Aggregate income shocks alone generate foreclosure rates that are too low. More details are discussed in Section 5.3.

rate could have been 1.0 percentage points higher (or 50 percent larger): 3.2 percent vs 2.2 percent in data. Given this eluded extra increase in foreclosure rates, the resulting gains due to avoided deadweight losses of foreclosure are much larger than the cost of implementing the program: a peak of 0.36 percent vs 0.12 percent of the equilibrium aggregate income, respectively.

The program also prevented house prices to fall slightly more, which benefited all households in the model. In particular, during 2009 and 2010, the drop in prices could have been 0.4 percentage points higher, on average, without HAMP. These small reductions translate into additional gains due to avoided house wealth losses of 2.0 percent of aggregate income, on average, during those same years. Overall, these results suggest that the benefits of HAMP exceed its costs, and this may hold despite the fact that house prices in the model fall only half of what they do in data.[10]

Finally, I explore how the Great Recession would have looked like if mortgage contracts were temporarily converted into Shared-Apreciation Mortgage (SAM) contracts. With these contracts, which were heavily advocated in the aftermath of the Great Recession, the principal or mortgage payments are written down if a local house price index falls, whereas they increase if such price index rises. The main motivation to examine this alternative policy is that, unlike the case of HAMP, the government would not have had to pay monetary incentives to neither banks nor households. I find that turning mortgages contracts into SAM contracts with 10-percent indexation (SAM-10) is less effective at taming foreclosure rates than HAMP–the peak is only slightly smaller than the one in the absence of the modification program–, but generates twice-as-large gains from avoided house wealth losses.

Related Literature

This paper primarily relates to both empirical and model-based strands of literature studying the effects of HAMP and debt forgiveness programs in general. In the first group, Voicu et al. (2011) and Scott (2015) study the performance of mortgages modified through the program vs privately-modified ones.[11] First, both papers document that HAMP modifications offer, on average, higher levels of payment reductions than non-HAMP modifications. Second, they both find that HAMP re-default rates are substantially lower than those of non-HAMP

[10] A discussion of this point can be found in Section 5.1.

[11] Voicu et al. (2011) study the performance originated in NYC during the period Jan-2008 through Nov-2010. Scott (2015) combines the CoreLogic Loan Performance subprime database with HAMP administration data, focusing on the period 2010-2011.

modifications, even after controlling for the level of payment reduction and other borrower-specific variables. Finally, both works find that principal reductions (in HAMP and private modifications) have a significant effect on decreasing re-default probabilities, but considerably smaller compared to that of payment reductions.[12] This paper heavily relies on the data analysis presented in both documents; in particular, for calibrating HAMP modifications' market share and the average payment reduction in private modifications.

Agarwal et al. (2013) evaluate the effectiveness of HAMP at increasing debt renegotiation and reducing foreclosure rates using two separate large datasets.[13] They estimate counterfactual levels of both variables with a difference-in-difference approach exploiting the variation in owner-occupancy status, given that only borrowers whose properties were classified as owner-occupied were eligible for HAMP.[14] They find that HAMP increased the intensity of renegotiations and caused a 0.37 percentage points decrease in the annual foreclosure rate, reaching just one-third of its targeted indebted households. They also find that this underperformance was in large part due to low renegotiation intensity of a few big intermediaries. This paper complements their work by estimating a counterfactual foreclosure rate for each year HAMP was active using a general-equilibrium framework, and by explicitly measuring the social costs and benefits of the program.

Ganong and Noel (2017) empirically estimate the effects of principal (long-term obligation) reduction, isolating it from that of payment (short-term obligation) reductions. To that end, they compare households who only get a payment reduction under HAMP with those who also get a principal reduction of US$ 70,000 on average, using both regression discontinuity design and a difference-in-difference approach. Their main finding is that such mortgage principal reduction had no impact on default or consumption for borrowers who remain underwater.[15] This result, the authors argue, highlights the importance of mortgage payment reductions in the design of effective mortgage modifications, which is aligned with the main conclusions of this paper.[16]

[12] Scharlemann and Shore (2016) find similar effects of principal forgiveness on redefault rates among HAMP participants.

[13] The first dataset matches detailed HAMP participation data to consumer credit bureau records. The second one comes from a large bank that is also a mortgage servicer. Finally, they study the period July 2008 through June 2012.

[14] Properties under an investor-owned label did not qualify, and were used as a control group.

[15] They also rationalize the result for consumption in partial-equilibrium life-cycle model. They find that when principal reductions do not push borrowers sufficiently above water so as to relax collateral constraints, consumption is unaffected because borrowers are unable to monetize increased housing wealth.

[16] As mortgages in this paper are one-period, principal reductions also imply payment reductions. Details are discussed on section 3.3.

Among model-based works, Hembre (2018) and Kaplan, Mitman, and Violante (2020) are the closest to this paper. Hembre (2018) performs the same counterfactual exercise–making HAMP not available–, in the context of a partial equilibrium model in which only HAMP participants are considered. The model includes income, house prices, and exit preference shocks to induce default, and allows homeowners to vary by an unobserved permanent attachment, or sentimental value to their home. Counterfactual simulations suggest that, among the program's participants, default/foreclosure rates could have been at least twice as high. Finally, *back-of-the-envelope* calculations by the author estimate that the social benefit is much smaller than the cost of the program.

Relative to his work, this paper makes progress on several fronts. First, while Hembre (2018) works in a partial-equilibrium environment focusing only on HAMP participants, this paper allows for both private and public mortgage modifications in a general-equilibrium framework. Second, it is not clear how house prices move in the counterfactual scenario of no-HAMP in Hembre (2018), as no assumption is explicitly mentioned. On the contrary, house prices in this paper are equilibrium objects, which is more convenient for determining the avoided house wealth loss of all households in the absence of HAMP.

Third, the ways in which his paper and mine measure benefits and costs are different. Costs in Hembre (2018), unlike this paper, include transfers of the US government to Fannie Mae and Freddie Mac attributed to the federal takeover of these government-sponsored enterprises (GSEs). These transfers, which are clearly not related to HAMP, are considered on top of those that do correspond to the program, as the GSEs guaranteed a certain fraction of mortgages. In regards to benefits, Hembre (2018) considers only the avoided reduction in home prices of households living in the vicinity of HAMP participants. This paper, on the other hand, includes the avoided extra reduction for all households plus the avoided deadweight loss of foreclosure incurred by banks and households.

On the other hand, Kaplan, Mitman, and Violante (2020) build a general-equilibrium model of the U.S. economy with multiple aggregate shocks (income, housing finance conditions, and beliefs about future house prices) that generate fluctuations in equilibrium house prices, and use it to study the housing boom and bust around the Great Recession. They find that the main driver of movements in house prices and rents was a shift in beliefs instead credit conditions, as it is usually assumed in the literature. They also investigate the potential role of debt forgiveness programs, and find that a large-scale program–considerably more generous than HAMP– would not have prevented the sharp drop in house prices, but would have significantly lessen the spike in foreclosures.

The findings for foreclosure rates in their counterfactual exercise are qualitatively similar to those in this document. In that sense, this paper complements theirs. There is, however, one main difference in assumptions that should be mentioned: in their base scenario, they assume that neither HAMP nor private modifications took place.[17] In contrast, both private and HAMP modifications are available in the factual scenario of this paper. In addition, while explicitly modelling an expectations channel allows them to better match the dynamics of house prices during the Great Recession, this also poses the additional problem of figuring out how beliefs would behave in a counterfactual exercise.[18]

More generally, this paper relates to several strands of literature on housing and financial macroeconomics.[19] This paper is also related to the literature that studies financial frictions and the business cycle, pioneered by Bernanke, Gertler, and Gilchrist (1996) and Kiyotaki and Moore (1997).[20] Finally, modeling-wise, this paper is connected to works that rely on general equilibrium models with heterogeneous agents subject to uninsurable idiosyncratic risk, housing, and defaultable mortgage contracts with endogenous interest rates. These include Corbae and Quintin (2014), Chatterjee and Eyigungor (2011), Guler (2015) and Jeske, Krueger, and Mitman (2013).

The rest of the document is organized as follows. Some stylized facts of the Great Recession along with a description of HAMP is presented in Section 2. The model is described in Section 3, while details on the calibration are presented in Section 4. Section 5 reports the main results, whereas section 6 concludes.

2 The Great Recession and Policy Response

2.1 The Housing and Mortgage Markets

This section documents some stylized facts of both the housing and the mortgage markets before, during and after the Great Recession of 2008-2009. Some of them are used as inputs,

[17] They argue that their scope was "too small" to be worth modelling, citing the findings in Agarwal et al. (2013).

[18] In the latest version of their paper, they assume that house price expectations remained the same in the counterfactual scenario with a large-scale debt forgiveness program.

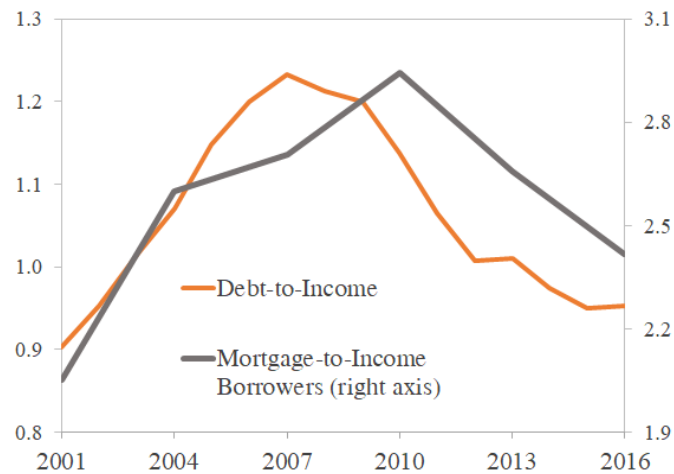
[19] See Davis and Van Nieuwerburgh (2015) for a review of this literature.

[20] See Jermann and Quadrini (2012) for a synthesis of the main types of financial frictions proposed in the literature applied in stylized model.

while others are used to evaluate the model's fitting in the main exercise of the paper.

The years prior to the Great Recession displayed a considerable increase in the levels of mortgage debt, followed by a sharp fall both during and in the aftermath of it. Figure 1 shows two different indicators of indebtedness. The first one is the aggregate nationwide debt-to-income ratio from the Financial Accounts of the United States, constructed by the Federal Reserve. This ratio increased 36.6 percent between 2001 and 2007, and fell by 22.7 percent between 2007 and 2016.

Figure 1: Households' Leverage in the U.S.



Note: Debt-to-Income corresponds to Aggregate Nationwide Debt-to-Income Ratio from the Financial Accounts in the U.S. (FAUS). Borrowers are defined as households in the Survey of Consumer Finance (SCF) with negative net financial-asset positions, which equals total value of financial assets minus total debt.

Source: Financial Accounts of the U.S. and Survey of Consumer Finance

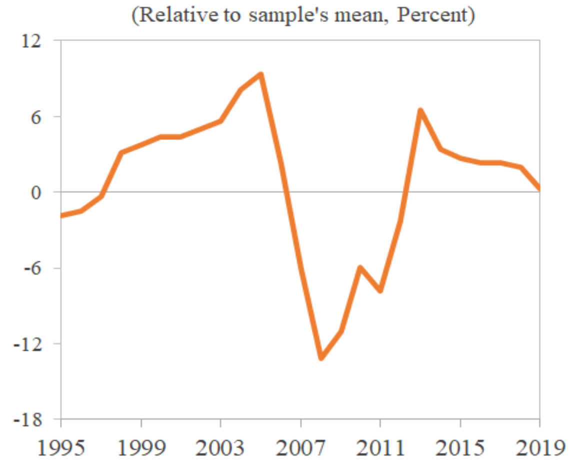
The second variable, which is taken from the Survey of Consumer Finance (SCF), is the average mortgage-to-income ratio for households with negative net financial-asset positions (Borrowers from now on).[21] This position equals total value of financial assets minus total debt.[22] This variable displayed a slightly more pronounced pattern than the first one: it

[21]This survey is released every three years. The latest available year is 2016.

[22]Given this definition, and the fact that around 80 percent of household debt is accounted by mortgage debt, it is expected that mortgage-to-income ratios of this type of households will be higher than the average total debt-to-income ratio.

increased 43.3 percent between 2001 and 2010, and decreased 17.8 percent between the years 2010 and 2016.[23]

Figure 2: Real House Price Growth Rate in the U.S.



Note: Real House Price corresponds to the S&P/Case-Shiller U.S. National Home Price Index, divided by the Personal Consumption Expenditures (PCE) Price Index. The sample's mean is calculated over the period 1995-2019, in annual frequency.

Source: Federal Reserve Economic Data (FRED).

Home prices also followed a very volatile path. Figure 2 shows the growth rate of the S&P/Case-Shiller U.S. National Home Price Index, deflated by the Personal Consumption Expenditure Price Index.[24] According to this indicator, home prices grew at a pace faster than sample's mean between 1998 and 2006.[25] In 2007, the growth rate was 6.0 percentage points below the sample's mean, while in 2008, it was 13.2 percentage points below.[26] On the other hand, the real mean family income fell 5.4 percent between 2007 and 2010 (Figure 3, left). In fact, the family income remained below its HP-filter trend between 2008 and 2015 (Figure 3, right).

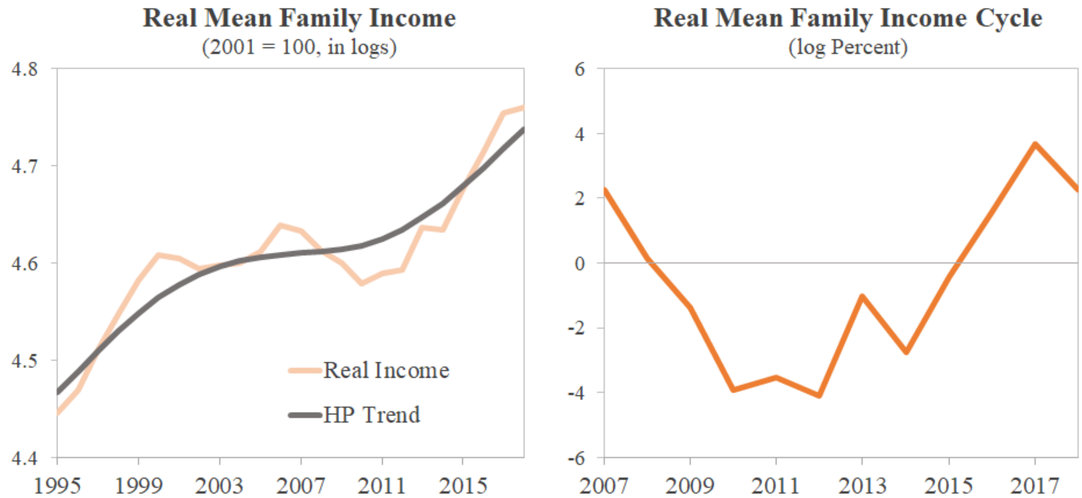
[23]The mortgage-to-income ratio of all households from the SFC is not included in the graph because it follows a very similar pattern to that of Borrowers, but at a lower level.

[24]I used growth rates for prices because the HP-filter cycle of house prices implied a mild "recession" on these prices, preceded by an extraordinary boom. This might be the case because of the unprecedented increase in home prices in the years prior to the great recession and the fact that the data is not long enough (the time series begins in 1987).

[25]Real house prices grew, on average, 1.6 percent annually, during the period 1988-2019.

[26]That is, the growth rate dropped 7.2 percentage points in 2008 with respect to that in 2007.

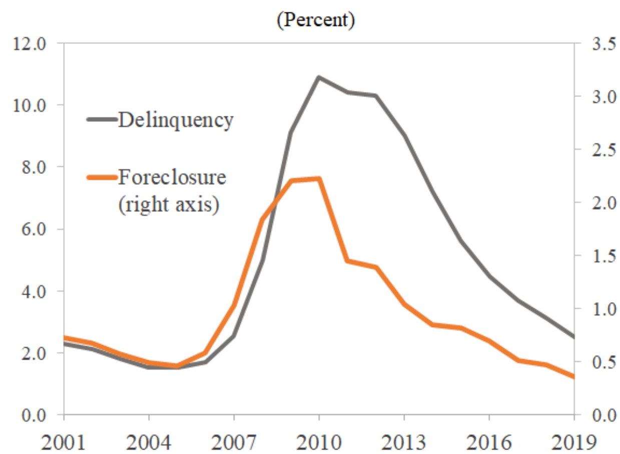
Figure 3: Family Income in the U.S.



Note: Real Mean Family Income is defined as the Mean Family Income in the U.S. over the Personal Consumption Expenditures (PCE) Price Index. HP Trend corresponds to the Hodrick-Prescott trend of the natural logarithm of Real Mean Family Income, while Real Mean Family Income Cycle is the difference between Real Mean Family Income and HP Trend.

Source: Federal Reserve Economic Data (FRED).

Figure 4: Default: Delinquency and Foreclosure Rates in the U.S.



Source: Federal Reserve Economic Data (FRED) and STATISTA.

Finally, mortgage default increased abruptly as well (Figure 4). Delinquent mortgages accounted for only 1.6 percent of total mortgages in 2005. In 2010, it was 10.9 percent of mortgages for which borrowers had failed to make payments on time (Figure 4, left axis). The fraction of mortgages that were both delinquent and in foreclosure process also increased sharply (Figure 4, right axis). In 2005, only 0.5 percent started a foreclosure process. In 2010, these mortgages added up to 2.2 percent of total mortgages.

2.2 Policy Response: HAMP

Different measures were implemented in response to the Great Recession.[27] HAMP, which was among them, was a loan modification program introduced in 2009, and offered homeowners who were at the risk of foreclosure a reduction in their monthly mortgage payments, down to 31 percent of their monthly income. This was achieved by either extending the mortgage term, or by reducing the principal and/or the interest rate. The objective was to make such payments affordable and sustainable. To that aim, the program included incentives to both homeowners and banks (servicers) so that modifying the loan was mutually beneficial. The program expired at the end of 2016.

Several requerements had to be met to have access to the program. Households needed to make more than 31 percent of their gross income on their monthly payments, had to prove financial hardship, and showed that they were able to make their monthly payments once the modification was set up. Moreover, the mortgage had to be delinquent or default was reasonably expected. Also, the property had to pass a net present value test, which was used to determine that the bank or investor currently holding the loan would make more money by modifying the loan rather than foreclosing. In addition, the mortgage had to be originated on or before January 1st, 2009.

The set of incentives included a 50 percent subsidy of the monthly payment reduction to banks or servicers, starting at 38 percent payment-to-income ratio, until reaching 31 percent, for five years at most. In addition, banks would get a lump-sum transfer of US$ 1,200 for each modification. Finally, both homeowners and banks would get lump-sum transfers of US$ 1,000 on a yearly basis, for five years, as long as the borrower did not default.[28]

[27] These include fiscal stimulus programs, conventional monetary policy along with forward guidance for the federal funds rate, and non-conventional actions like the large scale asset purchase and credit easing programs, among others.

[28] More details on eligibility criteria and compensations to both homeowners and servicers can be found on the Making Home Affordable Handbook.

On the other hand, the program also helped to set modification standards across the mortgage industry, and encouraged private lenders to modify mortgages in a more sustainable fashion, at no expense to taxpayers. On this point, Scott (2015) reports that, before HAMP, private modifications mostly consisted in recapitalizing missed interest payments and recalculating the borrower's payments based on the new, higher mortgage loan balance, without taking into account the actual homeowner's capacity to make such new payments on time. Not surprisingly, modifications completed in 2007 and 2008 experienced high re-default rates in the early months following the modification. In fact, once HAMP modifications were available, private modifications gradually became more sustainable and showed lower re-default rates than those observed during 2007 and 2008.[29]

3 The Model

3.1 Environment

The environment is similar to that in Condor (2020), except for the fact that default by a Borrower entails not only losing its entire housing stock, but a fraction of labor income as well. Details are presented below. Details on how HAMP was included in this framework are discussed in section 3.3.

Endowments. The economy has two types of goods. First, there is an idiosyncratic endowment of a non-durable good $\mu_y y$, where y follows a Markov process with unconditional mean equal to one, and μ_y is a constant scale factor. This constant μ_y is assumed to be non-stochastic and fixed in the stationary equilibrium, which implies by the Law of Large Numbers that the aggregate endowment of the non-durable good is equal to μ_y. This endowment can be interpreted as labor income when labor supply is fixed. Finally, recessions can be generated by "shocking" the value of μ_y and computing the transition path.

Second, there is perfectly a divisible durable good (housing) available in fixed supplied normalized to H_s.

Preferences. There are two types of households, a measure ψ of Impatient households ("Borrowers") with discount factor β; and a measure $(1-\psi)$ of Patient households ("Savers") with

[29] Redefault rates in private modifications were still higher than those from HAMP, in part, because HAMP modifications were more generous. See Voicu et al. (2011) and Scott (2015) for further details.

discount factor $\widetilde{\beta}$, where $\beta < \widetilde{\beta}$. Throughout the paper, for decision variables common to both types of households, x denotes Borrowers choices while $\widetilde{x}$ represents Savers choices.

Borrowers get a fraction κ of the non-durable aggregate endowment μ_y, while Savers get the remaining fraction $1 - \kappa$.[30] Households derive period utility $u()$ and $\widetilde{u}()$ from non-durable consumption (c and $\widetilde{c}$) and housing consumption which is proportional to the housing stock owned in that period (h and $\widetilde{h}$).[31] The housing good can be purchased every period at price p (relative to the non-durable good).

There is also a competitive bank, which is owned by Patient households ("Savers").

Assets. Households can buy, from the competitive bank, one-period deposits d' that pay a risk-free rate r^d. Households can also purchase houses, which are risky assets, subject to an idiosyncratic depreciation shock ω. At the beginning of each period, each household faces a realization of ω so that the effective housing stock is ωh_{-1}. The depreciation shock ω is i.i.d. across households, has lognormal cumulative distribution $F(\omega)$, $E(\omega) = 1$, and $\sigma = var(\ln \omega)$. While σ is assumed to be fixed in the stationary equilibrium, it can vary during the transition path following shocks to μ_y.

Mortgages. Households have access to a one-period fixed-rate mortgage contract offered by the competitive bank. Let Q denote the price schedule of such contract.[32] If a household takes a new mortgage, she gets Qm' in the current period and agrees to make a payment m' on the next period.

In addition to the FRM defined above, a SAM contract becomes available during the recession in one of the counterfactual exercises. In this contract, payments are indexed to the idiosyncratic depreciation shock ω. Specifically, next period payment is given by $(\omega')^{\iota} m'$, where ι is an indexation parameter. When $\iota = 0$, the contract becomes a one-period fixed-rate contract. As the SAM contract encompasses the FRM, all definitions will be stated in terms of the former.

Every household has the option to default on its mortgage obligations after observing the realization of its depreciation shock ω. When default is chosen, a household loses its entire housing stock, which is seized by the bank. In addition, such household loses a fraction h_y

[30] This implies that, every period, a Borrower gets $\frac{\kappa}{\psi}\mu_y y$, whereas a Saver gets $\frac{1-\kappa}{1-\psi}\mu_y y$.

[31] u and $\widetilde{u}$ must meet the minimum requirements for utility functions: non-decreasing and quasi-concave.

[32] The mortgage interest rate r^m is then given by $(1 + r^m) = 1/Q$.

of its labor income. There are no other costs for the household after default.[33] The bank then sells the house incurring in a proportional cost μ. This implies that, in the context of this model, the social cost of a defaulted mortgage (or total deadweight loss) is given by the sum of the cost banks incur in selling the seized house and the household's loss of labor income.

Finally, loan modifications of HAMP are temporary and only implemented during a recession. Details on the exact implementation are discussed later.

Big Family of Savers. As Borrowers are the main focus, it is also assumed that savers belong to large representative family of savers, so that they can diversify away any idiosyncratic risk. As a result, each household inside a family of savers consumes exactly the same amount of the durable good $\widetilde{c}$ and housing services $\widetilde{h}$. Also, at the end of each period, the family pools all its assets among its members.

Aggregate state. The aggregate state is given by the beginning-of-period distribution of housing stock and deposit/mortgages among the two types of households. I choose the asset distributions of Borrowers $(\Theta(h_{-1}, m))$, where h_{-1} denotes the initial housing stock of a Borrowers and m accounts for the initial promised mortgage payments for the period. Let $X = \{\Theta(h_{-1}, m)\}$ be the aggregate state of the economy.

3.2 No Loan Modifications

3.2.1 Borrower's Problem

Each Borrower starts the period with a portfolio $x = \{h_{-1}, m\}$ of housing stock and promised mortgage payments for that period. Each household also gets a realization of the non-durable good endowment y and learns what its idiosyncratic depreciation shock ω is.

Borrowers make default/payment decisions regarding current period's mortgage payments $\omega^{\imath} m$, then chooses consumption (c, h) along with next period's total mortgage obligations m' taking as given the mortgage contract with indexation $\imath$ and price schedule Q. I guess and later verify that the default decision at the family level is characterized by a threshold $\overline{\omega}$. That is, the household honors the promised payment when $\omega > \overline{\omega}$ and defaults otherwise. Let $D(\omega, y)$ be the default function associated with a threshold $\overline{\omega}$.

[33] No market exclusion and no recourse.

Given the mortgage contract with indexation ι and price schedule $Q(h, m', X)$, house price $p(X)$, and future decision rules, the recursive problem of a Borrower consists of choosing non-durable consumption c, housing stock h, total promised mortgage payments m' and a default decision $D(\omega, y)$ to solve

$$V(h_{-1}, m, y, X) = \max_{c,h,m',D} u(c, h) + \beta E_{y'} V(h, m', y', X') \quad \text{s.t.}$$

$$c + p(X, \iota)h \; + (1 - D(\omega, y))\omega^{\iota} m = \frac{\kappa}{\psi} \mu_y (1 - D(\omega, y)h_y)y \; + \\ (1 - D(\omega, y))\omega p h_{-1} + Q(h, m', X)\, m'$$

The left hand side of the budget constraint consists of non-durable consumption and housing consumption, as well as the promised mortgage payments $\omega^{\iota} m$ conditional on the default decision $(1 - D(\omega, y))$. The right hand side includes the endowment of the non-durable good y net of the default loss h_y, the value of houses kept conditional on the default decision $(1-D(\omega, y))\omega p h_{-1}$, and the resources from additional mortgages taken in the current period, which are determined by tomorrow's additional coupon payments $Q(h, m', X)\, m'$.

3.2.2 Saver's Problem

Inside the representative family of Savers, each household starts the period with the same portfolio $(\widetilde{h}_{-1}, d)$ of housing stock and one-period deposits. The family collects the endowments of the non-durable goods from all members, μ_y, which is equal to unconditional mean of y. It also collects the initial housing stock from all members, which is given by $\int \omega \widetilde{h}_{-1} dF(\omega) = E(\omega)\widetilde{h}_{-1} = \widetilde{h}_{-1}$.[34] Given the house price $p(X)$ and the risk-free interest rate $r^d(X)$, the recursive problem of a representative family of Savers consists of choosing non-durable consumption $\widetilde{c}$, housing stock $\widetilde{h}$, and new deposits d' to solve

$$\widetilde{V}(\widetilde{h}_{-1}, d, X) = \max_{\widetilde{c}, \widetilde{h}, d'} \widetilde{u}(\widetilde{c}, \widetilde{h}) + \widetilde{\beta} \widetilde{V}(\widetilde{h}, d', X') \quad \text{s.t.}$$

[34] Because $E(\omega) = 1$, the initial stock of housing, after all ω are realized, remains constant. Notice that, at this stage, there is heterogeneity at the member's level. However, the family pools its total housing stock among its members, and the heterogeneity disappears.

$$\widetilde{c} + p(\widetilde{h} - \widetilde{h}_{-1}) + \frac{d'}{1+r^d} = \frac{1-\kappa}{1-\psi}\mu_y + d + \text{div}$$

Notice that even though households in the representative family of Savers are also subject to idiosyncratic depreciation shocks, they are completely unaffected from this because, in equilibrium, they do not take any debt.

3.2.3 Banks and the mortgage price schedule

The competitive bank is owned by Savers, so when choosing a mortgage price schedule, they take into account Savers' stochastic discount factor (SDF). However, since there is no aggregate uncertainty, the SDF is always equal to one. Banks also take as given Borrowers' future decision rules, including the default decision. In equilibrium, given administrative costs θ, the mortgage price schedule $Q(h, m', X)$ satisfies:

$$Q(h, m', y, X)m = \frac{\int_{D'=0} \omega^{\iota} m' \, dF(\omega, y'|y) + (1-\mu)\int_{D'=1} \omega \; p'h \; dF(\omega, y'|y)}{(1+r^d)(1+\theta)}$$

If ω and y are independent, then:

$$Q(h, m', y, X) = \frac{E_{y'}\left[\Gamma(h, m', y', X')|y\right]}{(1+r^d)(1+\theta)}$$

where Γ satisfies

$$\Gamma(h, m', y', X')m' = \int_{\overline{\omega}'(y')}^{\infty} \omega^{\iota} dF(\omega) \; m' + (1-\mu)\int_{0}^{\overline{\omega}'(y')} \omega p'h \; dF(\omega)$$

$\overline{\omega}'(y')$ is tomorrow's default threshold and:

$$E_{y'}\left[\Gamma(h, m', y', X')|y\right] = \int \Gamma(h, m', y', X') dF(y'|y)$$

The function Γ accounts for the resources the bank gets for every unit of next period's promised coupon payment, given the household's total collateral h and the total promised coupon $(\omega')^{\iota}m'$, for a given realization of y'. It consists of two parts. The first one accounts for the non-defaulted fraction $\int_{\overline{\omega}'(y')}^{\infty} \omega^{\iota} dF(\omega)$ of next period's coupon payment m'. The second part is the value of the houses associated with defaulted mortgages $\int_0^{\overline{\omega}'(y')} \omega dF(\omega)\, p(X')h$, net of the foreclosure cost μ.

Finally, because there is no aggregate uncertainty, dividends are equal to zero in the stationary equilibrium, and are given by:

$$\text{div} = \frac{\psi}{1-\psi} \int E_y \left[\Gamma(h_{-1}, m, y, X; \iota)\right]\, m\, d\Theta \; - \; d$$

3.2.4 Stationary Equilibrium

Let $s = \mathbb{R}_+ \times \mathbb{R}_+ \times \mathbb{R}_+$ denote the individual state space of Borrowers, $\widetilde{s} = \mathbb{R}_+ \times \mathbb{R}_+$ the individual state space for Savers, and S be the aggregate state space.

A stationary recursive competitive equilibrium is a collection of decision rules of Borrowers $c,\ m',\ h,\ \overline{\omega} : s \times S \to \mathbb{R}$; decision rules of Savers $\widetilde{c},\ \widetilde{h},\ \widetilde{d} : \widetilde{s} \times S \to \mathbb{R}$; associated value functions $V : s \times S \to \mathbb{R}$ and $\widetilde{V} : \widetilde{s} \times S \to \mathbb{R}$, future decision rules $g^c,\ g^m,\ g^h,\ g^{\overline{\omega}} : s \times S \to \mathbb{R}$; prices $p,\ r^d : S \to \mathbb{R}$, mortgage price schedule $Q : s \times S \to \mathbb{R}$ and distribution Θ such that:

1. Decision rules and value functions solve both households' problems, taking future decision rules, p, r^d, and Q as given.

2. All markets clear:

$$\psi \left[\int \left(c_{(\omega,y)} + \theta(Qm')_{(\omega,y)} + \int_{D=1} (\mu\omega p h_{-1} + \frac{\kappa}{\psi}\mu_y h_y y) dF(\omega, y) \right) d\Theta \right] + (1-\psi)\widetilde{c} = \mu_y$$

$$\psi \int h_{(\omega,y)}\, d\Theta + (1-\psi)\widetilde{h} = H_s$$

$$\psi(1+\theta) \int (Qm')_{(\omega,y)}\, d\Theta = (1-\psi)\frac{d'}{(1+r^d)}$$

3. Θ is a stationary probability measure.

4. Current and future decision rules coincide for all possible states.

Finally, the deadweight loss due to foreclosure, which consists of the sum of the cost banks incur in selling seized houses and the household's loss of labor income, is given by

$$\psi \int \left(\int_{D=1} \left(\mu \omega p h_{-1} + \frac{\kappa}{\psi} \mu_y h_y y \right) dF(\omega, y) \right) \, d\Theta$$

3.2.5 Characterization of Equilibrium

This section develops the equilibrium conditions of some of the decision variables. In the case of Borrowers, the optimal default decision satisfies:

$$\overline{\omega} p h_{-1} + h_y y = \overline{\omega}^\iota m$$

In other words, the default rule is given by:

$$D(\omega, y) = \begin{cases} 1 \text{ when } \omega^\iota m > \omega p h_{-1} + h_y y \\ 0 \text{ otherwise} \end{cases}$$

This condition is just comparing the current cost of defaulting, which is given by the loss of housing stock of value $\overline{\omega} p h_{-1}$, with the honoring the mortgage obligation, $\overline{\omega}^\iota m$. On the other hand, the FOCs for the family of Savers reads:

$$\begin{aligned} \widetilde{u}_{\widetilde{c}} &= \widetilde{\beta}(1 + r^d)\widetilde{u}_{\widetilde{c}'} \\ p\widetilde{u}_{\widetilde{c}} &= \eta u_{\widetilde{h}} + p'\widetilde{\beta}\widetilde{u}_{\widetilde{c}'} \end{aligned}$$

where, in the case of the stationary equilibrium, $p = p'$ and $u_{\widetilde{c}} = u_{\widetilde{c}'}$. From the first equation, the risk-free interest rate can be pinned down in the stationary equilibrium as $1 + r^d = 1/\widetilde{\beta}$.

3.3 Including Loan Modifications

In this section, I introduce both HAMP and private modifications in the model. For simplicity, I assume that households can apply for a loan modification through HAMP with probability

$\aleph$, and to a private modification with probability $(1-\aleph)$. This assumption is fairly reasonable given the findings in Voicu et al. (2011), who report that differences in many observed characteristics between the HAMP and non-HAMP modified loans do not indicate that one set of loans is clearly "better" than the other, except for the fact HAMP modifications were more generous. Finally, modifications will follow through as long as mortgages meet elegibility criteria specific to each type of modification.

3.3.1 HAMP Modifications

Loan modifications resembling those from HAMP entail four additional elements: x (principal/payment reduction for Borrowers), $\widehat{x}/2$ (compensation to Banks for principal reduction, where $\widehat{x} \leq x$), and L_1 and L_2 (lump-sum transfer to Borrowers and Banks per modified loan, respectively). Details on each element of the loan modification and on eligibility criteria are discussed below.

Principal Reduction for Borrowers. The principal is reduced so that the payment-to-income (PTI) ratio reaches 31 percent. The principal reduction x is capped at 30 percent. Greater reductions are considered only if the loan modification benefits Banks.

Compensation to Banks. Banks are compensated for half of the reduction on the principal, starting at a PTI of 38 percent, until reaching a PTI of 31 percent ($\widehat{x}$). This means that, if a mortgage has a PTI of 40 percent, only half of the reduction of $38 - 31 = 7$ percent is compensated.

Lump-sum Transfers. For every modified loan, the household receives L_1 units of the non-durable good, while banks get L_2. This means that the total cost per modified loan is given by $\widehat{x}/2\ \omega^{\iota} m + L_1 + L_2$, which are financed by lump-sum taxes on everyone (Tr).

Eligibility. First, households must have a PTI ratio greater than 31 percent. In the context of a model in which debt contracts are one-period, it is possible to define the mortgage payment as the household's own resources needed to pay back the original debt, after having taken new debt promising the same total payment as the one in the current period, and using no additional collateral. Then, the PTI is simply the formerly defined mortgage payment as a fraction of income:

$$PTI = \frac{\omega^{\iota} m - Q(\omega h, m, y, X) m}{\frac{\kappa}{\psi} \mu_y y}$$

Second, households need to be in financial hardship and default/foreclosure is expected in the absence of the loan modification. In the context of this model, financial hardship can be defined as the current income being below a certain level of the unconditional mean of the income process in the stationary equilibrium. That is, when $y < (1-a)\mu_y^{SE}$, where $0 < a < 1$. Default must be expected according to the default rule $D(\omega, y)$.

Third, with the loan modification, households have the incentives to pay back the mortgage:

$$(1-x)\omega^i m - L1 < \omega p h_{-1} + h_y y$$

Finally, banks have greater profits when modifying the loan than when seizing the house and selling it incurring in a cost:

$$(1-\mu)p\omega h < (1-\widehat{x}/2)\omega^i m + L_2$$

3.3.2 Private Modifications

Private modifications, on the other hand, are assumed to reduce the mortgage principal/payment by a fixed ϕ percent. In regards to the eligibility criteria, I assume that 3 conditions must be met. First, default must be expected according to the default rule $D(\omega, y)$.

Second, with the loan modification, households have the incentives to pay back the mortgage:

$$(1-\phi)\omega^i m < \omega p h_{-1} + h_y y$$

Finally, banks make greater profits with the modified loan than with seizing the house and selling it:

$$(1-\mu)p\omega h < (1-\phi)\omega^i m$$

3.3.3 Including Modifications in the Model's Equations

Let $M^i(\omega, y, m, h_{-1})$ be the modification rule, which is equal to one when all eligibility conditions are met, and equal to zero otherwise, for $i = \{H, P\}$ denoting HAMP and private modifications respectively. In addition, let $1_\aleph$ be a random variable which is equal to one with probability $\aleph$, and zero otherwise. In other words, $1_\aleph$ is the random indicator function of Borrowers having access to a HAMP modification. Finally, let $M(\aleph)$ be the "consolidated" modification rule is given by

$$M(\aleph) = 1_\aleph M^H(\omega, y) + (1 - 1_\aleph) M^P(\omega, y)$$

The Borrower's budget constraint changes to:

$$\begin{aligned} c + ph \; &+ (1 - D(\omega, y))\omega^\iota m + \; 1_\aleph M^H(\omega, y)((1-x)\omega^\iota m - L_1) \\ &+ \; (1 - 1_\aleph) M^P(\omega, y)(1-\phi)\omega^\iota m \; = \\ &\frac{\kappa}{\psi}\mu_y\{1 - [D(\omega, y) - M(\aleph)]h_y\}\, y \; + \; \{1 - [D(\omega, y) - M(\aleph)]\}\omega p h_{-1} \\ &+ \; Qm' + -Tr \end{aligned}$$

Dividends are now given by:

$$\begin{aligned} \text{div} \;\; = \;\; &\frac{\psi}{1-\psi}\int \left(E_y\left[\Gamma(h_{-1}, m, y, X; \iota)\right] m\right) d\Theta \\ &+ \frac{\psi}{1-\psi}\int \left(\int_{M^H=1, 1_\aleph=1}\left[(1 - x + \tfrac{\widehat{x}}{2})\omega^\iota m + L_2 - (1-\mu)\omega p h_{-1}\right] dF(\omega, y)\right) d\Theta \\ &- d \end{aligned}$$

and the lump-sum taxes Tr are given by:

$$Tr = \psi \int \left(\int_{M^H=1, 1_\aleph=1}\left[\tfrac{\widehat{x}}{2}\omega^\iota m + L_1 + L_2\right] \, dF(\omega, y)\right) d\Theta$$

which are also present in Savers' budget constraint. Finally, the market clearing conditions in the Goods market are given by:

$$\psi\left[\int \left(c_{(\omega,y)} + \theta(Qm')_{(\omega,y)} + \int_{D=1, M=0}\left(\mu\omega \; ph_{-1} + \frac{\kappa}{\psi}\mu_y h_y y\right) dF(\omega, y)\right) \; d\Theta\right] + (1-\psi)\widetilde{c} = \mu_y$$

Finally, the deadweight loss due to foreclosure is given by

$$\psi \int \left(\int_{D=1, M=0}\left(\mu\omega \; ph_{-1} + \frac{\kappa}{\psi}\mu_y h_y y\right) dF(\omega, y)\right) \; d\Theta$$

4 Calibration

The main exercise of the paper consists in generating a recession similar to the Great Recession of 2008-2009, and study the role of loan modification program HAMP. In the first place, I assume that the economy is initially in its stationary equilibrium (2007).[35] This initial equilibrium is calibrated to match most of the moments observed in 2016. Also, I assume that HAMP is available only between the years 2009 and 2016. A summary of the calibration for an annual frequency is shown in Table 1. Details are discussed below.

Income Process. The idiosyncratic non-durable good endowment y is assumed to be an AR(1) process of the form:

$$\log y = \rho \log y_{-1} + (1-\rho^2)^{1/2}\varepsilon$$

where $E(\varepsilon) = 0$, $E(\varepsilon^2) = \sigma_\varepsilon^2$, and ρ is the one-period autocorrelation, whereas σ_ε is the unconditional standard deviation. Notice that with this functional form, the unconditional mean of y is equal to 1. Recent estimates[36] of the income process for heterogeneous-agent models report $\rho = 0.98$ and $\sigma_\varepsilon = 0.3$ on average. I choose those values, and approximate this AR(1) process with a 5-state Markov chain using Tauchen and Hussey's (1991) algorithm.

In addition, μ_y is equal to 1.0 to calculate to stationary distribution. Then, during the recession, it is set such that it matches the pattern of the cyclical component of the Real Family Income between 2008 and 2015, and to 1.0 from then on.

Demographics and Income Shares. The mass of Borrowers (ψ) and Savers ($1-\psi$) is pindowned by calculating a net financial-asset position for households in the 2016's Survey of Consumer Finance (SCF-16). This net position equals total value of financial assets minus total value of debt. Borrowers are defined as those with a negative position, and represent 48 percent of households in the survey. Also, with this definition, they account for 32.5 percent of total household income, which is the value assigned to κ.

Foreclosure Cost. A value a 0.22 is chosen for banks' foreclosure parameter μ, following the work of Pennington-Cross (2006) studying the liquidation sales revenue from foreclosed

[35]Notice that the U.S. economy was far being in equilibrium in 2007. However, matching that pattern would also imply generating the boom previous to the Great Recession, which is beyond the scope of this paper. The effects of this assumption on the results are discussed in the next section.

[36]See Storesletten et al. (2004).

houses using national data. The cost of foreclosure for households h_y is set at 0.056, considering the sum of the average moving expenses in 2008 scaled by the factor $\frac{\kappa}{\psi}$ (US$ 1,267) and two months of temporary rent in 2008 before reallocating to a new home (US$ 868 each month), as a percentage of Borrowers's average income in 2008 (US$ 53,919). Such average income is defined as the fraction $\frac{\kappa}{\psi}$ of 2008's mean family income in the US (US$ 79,634).

Depreciation Shock. The depreciation shock ω follows a lognormal distribution with mean one and $\sigma = var(\ln \omega)$. Notice that, in the model, both default and foreclosure take place in the same period. In the real world, only a fraction of delinquent mortgages ends up being foreclosed two years after the initial date of default on average. The average foreclosure rate between 2001 and 2019 was 0.97 percent, which is chosen as a target for the default rate in the stationary equilibrium of the model. This results in a value of 0.08 for σ.

Finally, during the transition path in which HAMP is available, the value of σ is set such that the default rate during the transition path matches the foreclosure rate observed between the years 2008 and 2016, and to its equilibrium value from 2017 on.

Preferences. The period utility functions have the form

$$\begin{aligned} u(c,h) &= \ln c + \eta \ln h \\ \widetilde{u}(\widetilde{c},\widetilde{h}) &= \ln \widetilde{c} + \widetilde{\eta} \ln \widetilde{h} \end{aligned}$$

Parameters η and $\widetilde{\eta}$ are chosen to match the average housing-wealth-to-income ratios of Borrowers and Savers on SCF-16, under the definition previously given. The average ratio for Borrowers is 4.14, while that of Savers is 4.51, which imply values of η and $\widetilde{\eta}$ of 0.063 and 0.060 respectively. The discount factor of Savers, $\widetilde{\beta}$, is set at 0.99 to match an equilibrium risk-free rate of 1%. The discount factor of Borrowers, β, is set at 0.92 to match a mortgage-to-income ratio of 2.42 for Borrowers.

Mortgage. The administrative cost per unit of mortgage issued, θ, is set at 40 basis points, following Jeske et al. (2013).[37]

Housing stock. The median house-price-to-income ratio during the period 2015-2019 was 3.2. On the other hand, the median rent-to-income ratio was of only 0.2. An average of the two is chosen, 1.70, which is generated by a fixed housing stock H_s of 2.5.

[37] In their paper, banks have to pay 10 basis points for administrative fees and 30 basis points for insurance.

Loan modifications. HAMP's transfers to borrowers (L_1) and banks (L_2) per modified loan are set to 0.013 and 0.028, respectively, which correspond to US$ 1,000 and US$ 2,200, as a percentage of mean family income in 2008 (US$ 79,634). In addition, the probability of accessing a HAMP modification ($\aleph$) is set at 0.31 to match a HAMP's market share of 38%, which is the average participation reported in Voicu et al. (2011) and Scott (2015). Finally, the payment reduction in private modifications (ϕ) is fixed at 24% so that this amount is about 2/3 of the average HAMP reduction in the model (36%).

Table 1: Calibration

Exogenously Calibrated Parameters

Param	Description	Value	Source / Target
ρ	Income persistence	0.98	Storsletten et al. (2004)
σ_ε	Income volatility	0.3	Storsletten et al. (2004)
μ	Banks' foreclosure cost	0.22	Pennington-Cross (2006)
h_y	Households' foreclosure cost	0.055	Moving expenses and rent (2008)
θ	Mortgage administrative cost	40 BP	Jeske et al. (2013)
ψ	Mass of Borrowers	0.48	SCF-16 net financial-asset positions
κ	Borrowers' income share	0.325	SCF-16 income shares
H_s	Housing Stock	2.5	House-price/Income 1.7
L_1	HAMP transfers to Borrowers	0.013	Percentage of family income 2008
L_2	HAMP transfers to Banks	0.028	Percentage of family income 2008

Endogenously Calibrated Parameters

σ	Volatility of depreciation shock	0.08	Default rate 3.0%
$\widetilde{\eta}$	Savers' house preference	0.060	Housing-to-income of 4.51 (SFC-16)
η	Borrowers' house preference	0.063	Housing-to-income of 4.14 (SFC-16)
$\widetilde{\beta}$	Discount Factor Savers	0.99	Risk-free rate 1%
β	Discount Factor Borrowers	0.92	Mortgage-to income of 2.43 (SFC-16)
$\aleph$	Probability of accessing HAMP	0.31	HAMP's market share 38%
ϕ	Private payment reduction	0.24	2/3 of model's HAMP reduction

5 Results

5.1 Effects of HAMP

The results of the main exercise of this paper are presented in Figure 5. The series under the label "HAMP" represent the results in a scenario in which the aggregate income (μ_y) resembles the path of the cyclical component of the real mean family income, the standard deviation of the idiosyncratic valuation shock (σ) is set such that the foreclosure rate matches that in the data, and HAMP is available. The "No HAMP" labels, on the other hand, denote the results in which no loan modification was made (private nor public), while still feeding the paths of μ_y and σ computed in the first scenario.

The house price path generated by the model with HAMP follows a reasonably similar trajectory to that of the real house price growth rate in the data. However, some differences are worth commenting. First, while price growth was already 6.0 percentage points below trend in 2007 and by 13.2 percentage points in 2008, prices in the model fall considerably in 2009 and 2010. This is the case because, in the model, home prices follow aggregate income closely. Second, the model generates drops in prices that are modest when compared to those in the data: a trough of only 4.9 percent below trend, compared to the 7.2 percentage points drop of the growth rate in home prices between 2007 and 2008.

On the other hand, the mortgage-to-income ratio of Borrowers displays a through of 16.6 percent below the equilibrium level, which is slightly smaller than the drop of this ratio observed in the data (17.8 percent in SCF), and smaller than the drop recorded on the aggregate debt-to-income ratio from the Financial Accounts (22.7 percent). Notice, however, that while mortgage debt in the model was on its equilibrium level in 2007, both ratios were around their historically highest levels. Overall, the model is capable of generating a recession that is qualitatively similar to the Great Recession.

In regards to counterfactual exercise, the main result is that, without the loan modification program, the peak in the foreclosure rate could have been 1.0 percentage points higher (or 50 percent larger): 3.2 percent vs 2.2 percent in data.[38] Given this eluded extra increase in foreclosure rates, the resulting gains due to avoided deadweight losses of foreclosure mostly incurred by banks are much larger than the cost of implementing the program: a peak of 0.36 percent vs 0.12 percent of the equilibrium aggregate income, respectively.

[38] In other words, in such peak, 3.2 percent of Borrowers could have had their houses seized. Because of HAMP, only 2.2 did.

The program also prevented additional drops in both mortgage levels and house prices. In particular, during 2009 and 2010, the drop in prices could have been 0.4 percentage points higher, on average, without HAMP. This small reduction translate into additional gains due to avoided house wealth losses, for all households, of 2.0 percent of aggregate income, on average, during those same years.

So far, these results suggest that the benefits of HAMP far exceed its costs. However, given that the model generates price drops that are smaller than those in the data, it is worth exploring how this point may affect the computed social gains from the program. To this end, more assumptions are required, particularly on how house prices would have behaved in the absence of HAMP. Recall that, with HAMP, prices fall 4.9 percent in the model; without the program, they would fall 5.4 percent.

If the decline rates in house prices were to be doubled in partial-equilibrium fashion–4.9 to 9.8 with HAMP, and from 5.4 to 10.8 without HAMP–, then the avoided drop in house wealth would also double. Moreover, even though this double-sized fall in house prices would also reduce the gains from the avoided dead-weight loss of foreclosure in 50 percent, by construction, the magnitude of the former gains is many times that of the latter. On the other hand, if instead it is assumed that prices follow the same path with and without HAMP–prices with and without HAMP fall 9.8–, then the avoided drop in housing wealth would be equal to zero, but the avoided deadweight loss of foreclosure would still be larger than the cost of implementing the program. Thus, with a more realistic house price drop, HAMP's benefits may still remaining in positive ground.[39]

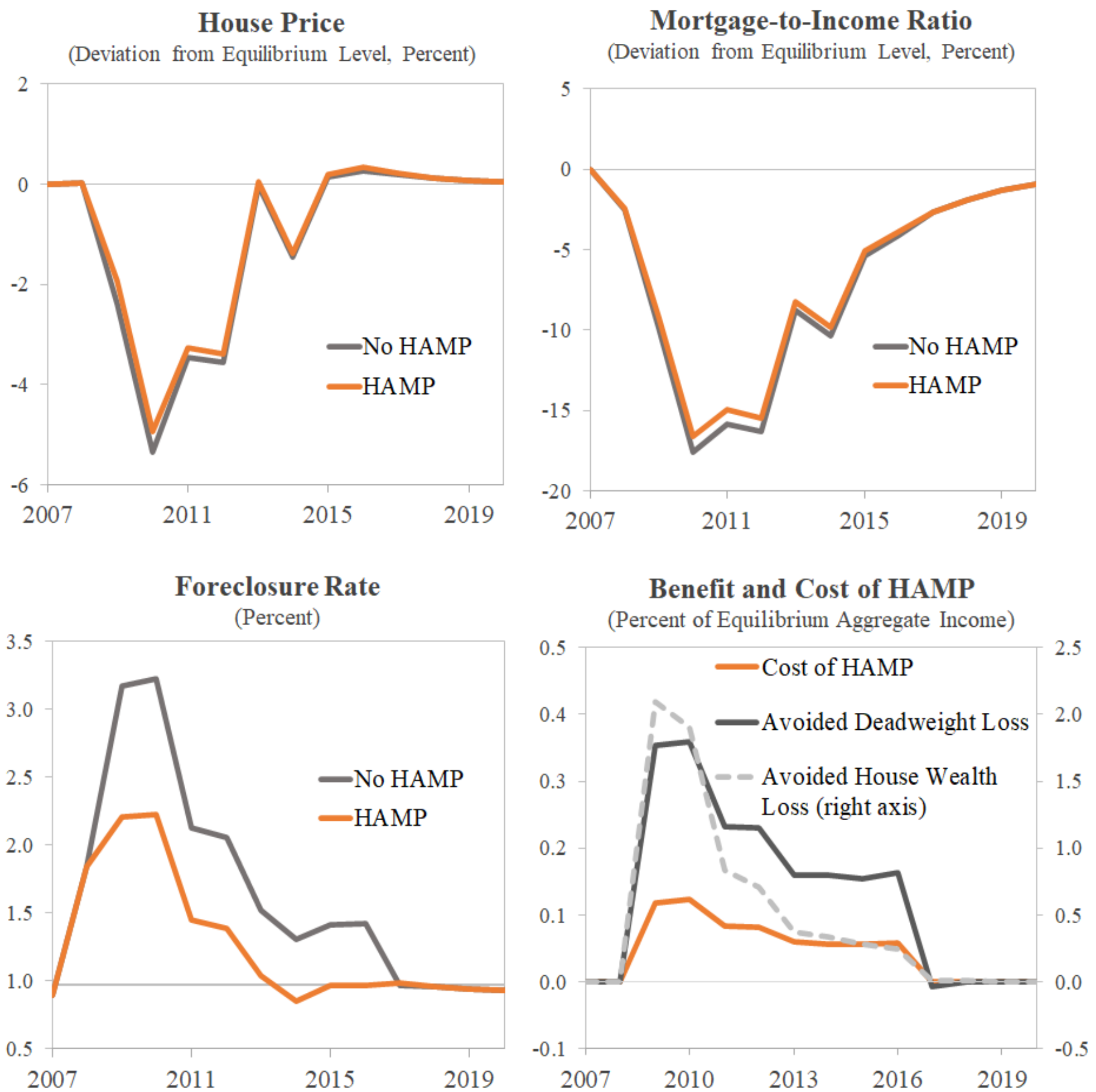
5.2 The Role of Sigma

In this subsection, the role of the volatility of the idiosyncratic depreciation shock on the model's fit is examined. In particular, it compares a financial recession (a drop in aggregate income μ_y along with higher volatility of the depreciation shock σ), with a more traditional recession (only a fall in aggregate income, with a fixed value of σ), in a scenario which the modification program is not implemented.[40] Results are displayed in Figure 6.

[39] Notice that if house prices drops in the model increased, mechanically, the levels of the depreciation shock's volatility required to match foreclosure rates in the data would be smaller. On this point, one big assumption in this partial-equilibrium "thought experiment" is that these two opposite forces do not change the counterfactual foreclosure rate considerably.

[40] The results for the case in which HAMP is available are quantitatively similar.

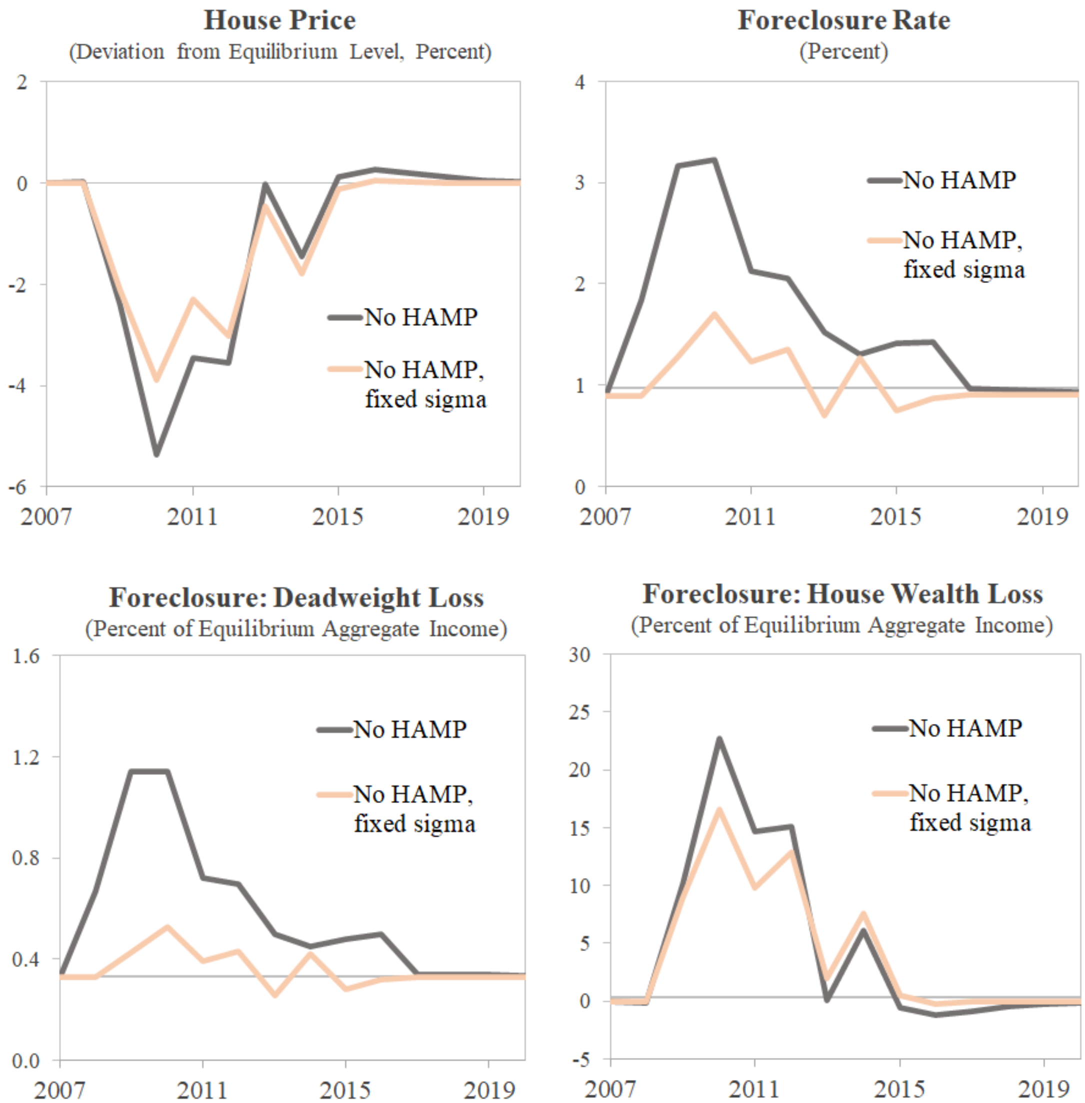
Figure 5: Results in the Absence of HAMP



Note: "HAMP" labels correspond to the scenario in which the aggregate income resembles the path of the cyclical component of the Real Mean Family Income, the standard deviation of the idiosyncratic valuation shock is set such that foreclosure rates match those in the data, and HAMP is available. The "No HAMP" labels, denote the results in which no loan modification is made (private nor public), while still feeding the paths of the aggregarte income and the standard deviation of the idiosyncratic valuation shock computed in the first scenario.

Source: Federal Reserve Economic Data (FRED), STATISTA, and own calculations.

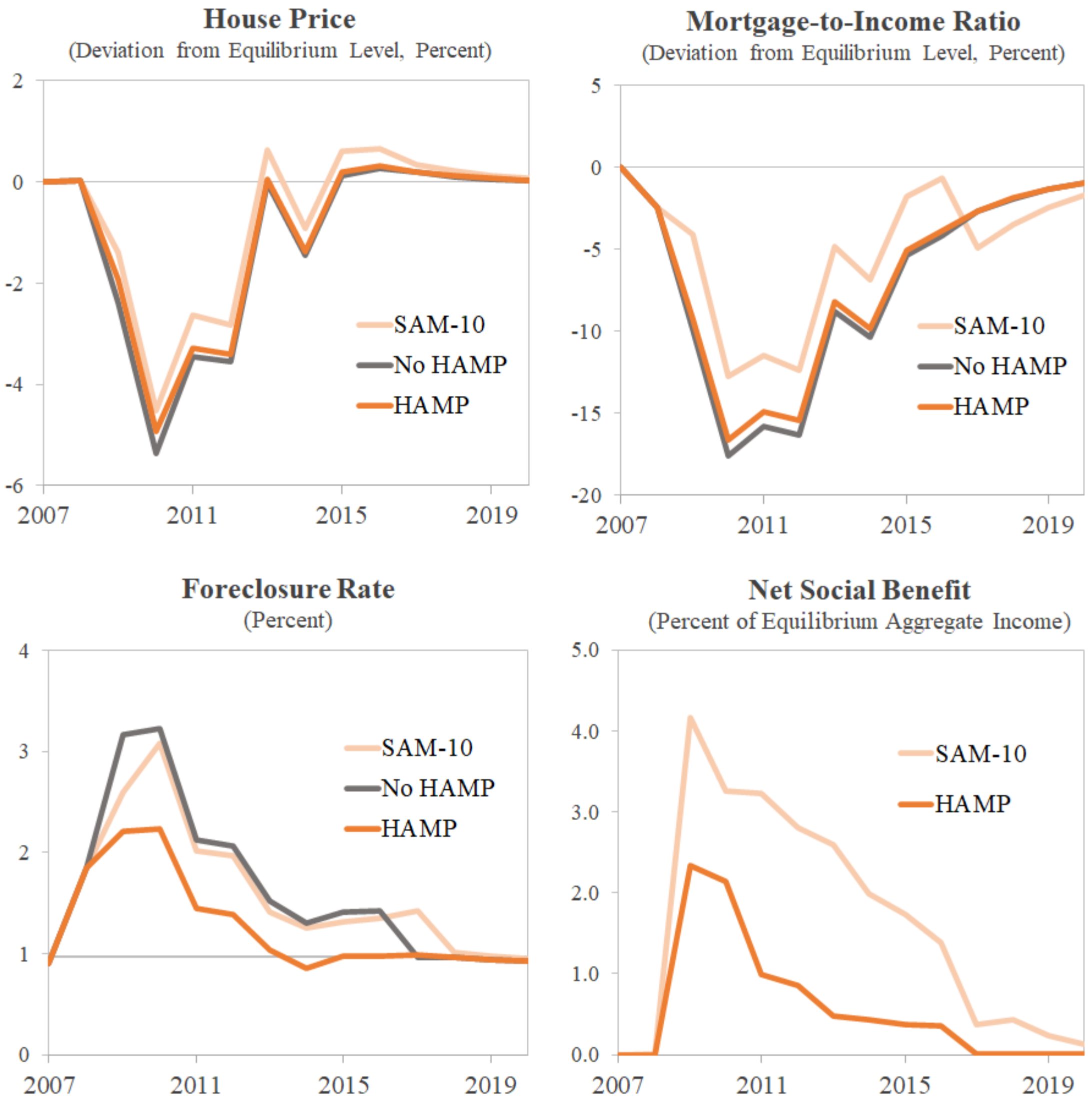
Figure 6: Results with Fixed Sigma and No HAMP



Note: "No HAMP" labels, denote the results in which no loan modification is made (private nor public), while still feeding the paths of the aggregarte income and the standard deviation of the idiosyncratic valuation shock computed in the "HAMP" scenario. "No HAMP, fixed sigma" labels correspond to a scenario similar to the "No HAMP" case, except for the fact that the standard deviation of the idiosyncratic valuation shock is kept fixed throughout the transition path.

Source: Federal Reserve Economic Data (FRED), STATISTA, and own calculations.

Figure 7: Results with SAM Contracts



Note: "HAMP" labels correspond to the scenario in which the aggregate income resembles the path of the cyclical component of the Real Mean Family Income, the standard deviation of the idiosyncratic valuation shock is set such that foreclosure rates match those in the data, and HAMP is available. "No HAMP" labels, denote the results in which no loan modification is made (private nor public), while still feeding the paths of the aggregarte income and the standard deviation of the idiosyncratic valuation shock computed in the first scenario. "SAM-10" labels correspond to the case in which mortgage contracts are converted into SAM contracts witha 10-percent indexation, and HAMP is not available.

Source: Federal Reserve Economic Data (FRED), STATISTA, and own calculations.

First, a fixed volatility of the depreciation shock during the recession generates smaller drops in both house prices and mortgage debt levels. In fact, with a fixed value of sigma, the paths of those variables follow closely the path of aggregate income depicted in Section 2. Second, the shocks in aggregate income alone do not generate high enough foreclosure rates. In fact, even with the absence of the loan modification program, they are still below those observed in the data. These two results imply that, in general, financial recessions could be more costly than traditional ones, both in terms of deadweight and house wealth losses associated with foreclosure (see bottom row in Figure 6).

5.3 SAM instead of HAMP

Shared-Appreciation mortgage (SAM) contracts were advocated as an alternative to mitigate the effects of a financial recession.[41] In these contracts, the principal or mortgage payments are written down if a local house price index falls, whereas they increase if such price index rises. In fact, one interesting hypothesis to test is whether this alternative policy would have generated similar benefits but with considerably smaller costs, as the government would not have had to pay monetary incentives to neither banks nor households. This section examines how the Great Recession would have looked like if fixed-rate contracts were temporarily converted into SAM contracts with a 10-percent indexation (SAM-10). For such exercise, the economy follows the paths of μ_y and σ previously computed, and the conversion to SAM contracts takes place between 2009 and 2016. Results are presented in Figure 7.

First, house prices would have had a less pronounced drop than the scenarios with HAMP and No HAMP, along with a stronger recovery around 2013. Similarly, mortgage debt levels would have decreased considerably less. However, the fall would have been more persistent than the first two scenarios. Third, foreclosure rates would have been only slightly smaller than those in the absence of the modification program; that is, almost 50 percent larger than those registered with HAMP. In other words, this policy would not have been effective at taming foreclosure rates. However, as prices fall less than with HAMP, gains from avoided house wealth losses are almost twice as large, which makes the estimated net social benefits of this alternative policy greater than those of HAMP.

[41] Recall that a financial recession is defined as one that displays both a fall in aggregate income and higher volatility in the idiosyncratic depreciation shock.

6 Conclusion

HAMP was loan modification program introduced in 2009 to help highly indebted homeowners avoid foreclosure. When a loan was modified, mortgage payments were reduced to 31 percent of a household's income and banks were partially compensated for such reduction. The program also encouraged private lenders to modify mortgages in a more sustainable fashion given that, before HAMP, private modifications basically consisted in recapitalizing outstanding arrears. This paper studies the role of this program in decreasing foreclosures rates during and after the Great Recession, in the context of a general equilibrium model with heterogeneous agents, two types of households (Borrowers and Savers), and uninsurable idiosyncratic risk, in which both HAMP and private modifications are available. The benefits and costs of HAMP are examined in detail.

The main result is that, without the loan modification program, the peak in the foreclosure rate could have been 50 percent larger (3.2 percent vs 2.2 percent in data). In addition, gains due to a reduction in the deadweight cost of foreclosure are much larger than the cost of implementing the program (a peak of 0.36 percent vs 0.12 percent of the equilibrium aggregate income), whereas gains due to avoided house wealth losses peak at 2.0 percent of aggregate income. This suggest that the benefits of HAMP far exceed its costs. On the other hand, an alternative policy consisting on temporarily converting mortgages into Shared-Appreciation Mortgage (SAM) contracts would have been less effective at taming foreclosure rates, but would have generated twice-as-large gains from avoided house wealth losses.

This paper contributes to the strand of literature studying mortgage markets and loan modifications during the Great Recession, in a general-equilibrium framework in which both HAMP and private mortgage modifications can be accessed. Several extensions could be studied in this framework. These include: working with long-term mortgage contracts, adding a life-cycle dimension, and explicitly modelling a renting market. These extensions are left for future research.

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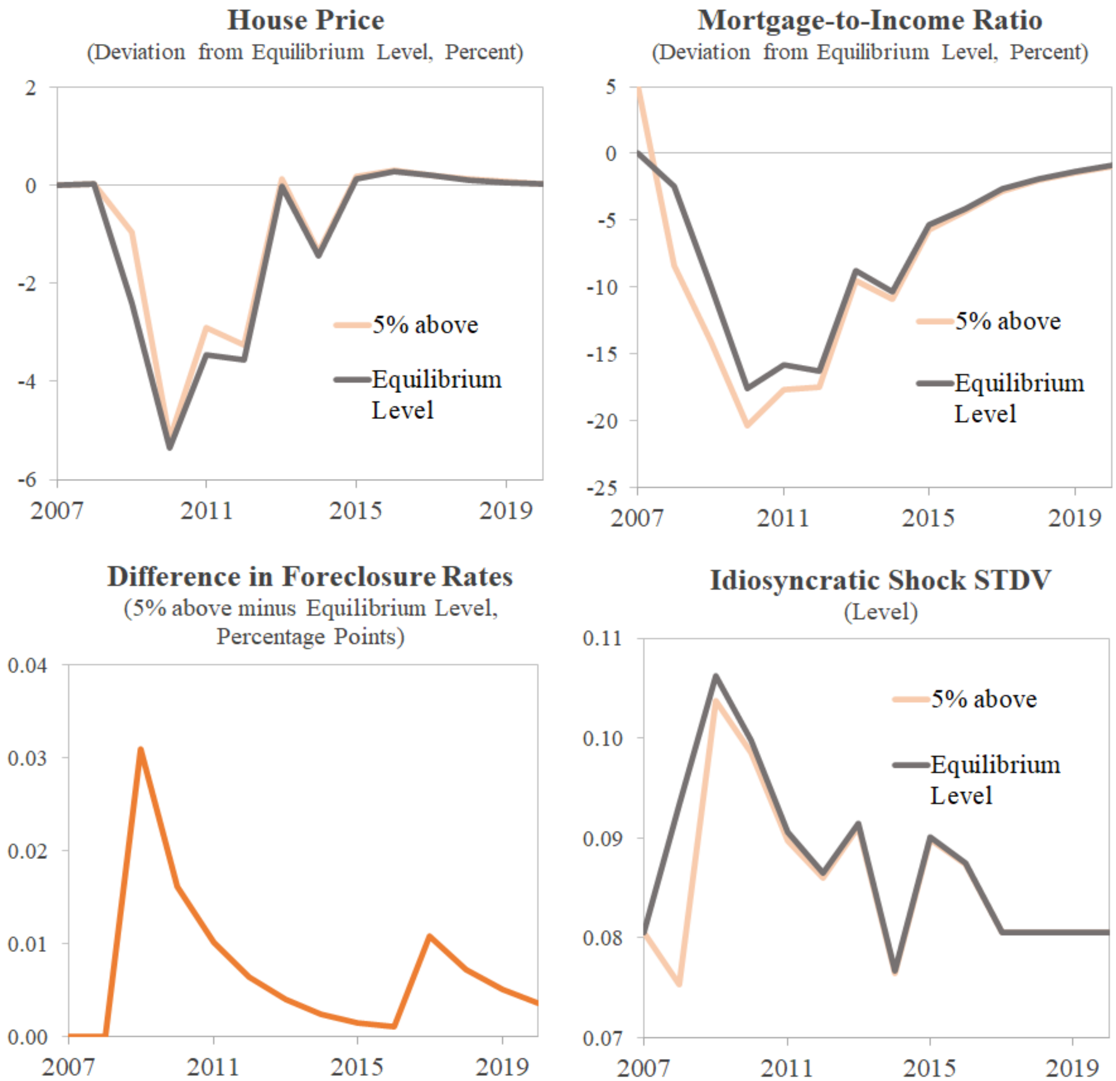
7 Appendix

7.1 Higher Initial Mortgage Level

In the main exercise of the paper, it is assumed that the economy is initially in its stationary equilibrium. In that sense, it resembles an impulse-response function of the model economy to shocks on both aggregate income and the volatility of the house valuation shock. This subsection explores how the foreclosure rate computed in the absence of HAMP would change if the economy in the model was not initially in its stationary equilibrium, like data suggest for the year 2007. In particular, it examines the case in which all Borrowers have initial mortgage debt levels 5 percent above those corresponding to the stationary equilibrium. The results are presented in Figure 8.

The resulting foreclosure rate along the transition path is only marginally higher in this case: the difference with respect to the case in which the economy is initially in its stationary equilibrium is below 0.04 percentage points. Moreover, the path of both the house price and the mortgage-to-income ratio are fairly similar to the equilibrium case. Finally, as mortgage debt is initially higher, the volatility of the idiosyncratic depreciation shock needed to match the observed foreclosure rates is initially smaller, a result that is expected given the fact that the probability of default is increasing in the level of debt.

Figure 8: Initial Mortgage Debt 5% above Equilibrium Level and No HAMP



Note: "Equilibrium Level" labels, correspond to the "No HAMP" case, and highlights the fact that the economy is initially in its stationary equilibrium (2007). "5% above" labels correspond to a scenario in which HAMP is not implemented, all households in the economy have mortgage debt 5% above their stationary equilibrium levels, the aggregate income resembles the path of the cyclical component of the Real Mean Family Income, and the standard deviation of the idiosyncratic valuation shock is recomputed using an intermediate (not reported) case in which HAMP is available and mortgage debt is 5% above its equilibrium level ("HAMP, 5% above").

Source: Federal Reserve Economic Data (FRED), STATISTA, and own calculations.